University of Edinburgh.

THESES PRIZE COMPETITION.

Thesis by Oliver Henry Blacklay

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Some points in the Anatomy of the base of the Skull, in reference to the part played by the base in the evolution of the skull from the lower to the higher types.

Thesis

for the degree of M.D.

by

Oliver Henry Blacklay, M.B. Ch.B.

Edinburgh, 1910.

March 1913.

The work included in the following pages was commenced with the object of investigating the changes - if any - which take place in the base of the human skull as it is traced from those types which we regard as lowest in the evolutionary scale up to the highest: Further, of determining the significance of these changes. whether they are to be regarded as evidence of an evolutionary process which has been taking place in the base and whether this process is dependent on or secondary to the development of the skull elsewhere or is due to an independent development of the base along lines peculiar to itself and irrespective of the changes which might be taking place in other parts of the skull.

As regards the results of the investigation, it might be convenient to state at once the main conclusions arrived at. In reference to the first point it was found that skulls exhibit considerable difference in the structure of the base according as they are taken from what we are accustomed to describe a high or a low class.

Briefly the main differences between lower and higher type skulls are as follows :-

1. The base becomes absolutely as well as relatively broader.
2. The petrous part of the temporal bone tends

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to assume a more transverse position in the skull.

3. The length of the nasion basion line tends to become shorter.

4. The basi occipital becomes set at a greater slope to the horizontal plane through the basion.

5. The petrous temporal bone undergoes marked changes especially as regards its relation to its adjacent bones.

As to the significance of these differences it may be stated that they appear to afford definite evidences that a gradual development has been taking place in the skull base by reason of which the whole aspect of the base has become materially altered - that just as other parts of the skull have become markedly altered as it is traced from the lowest to the highest type so also the base has not remained at a standstill but has been undergoing changes, as varied and as important; that these two sets of changes, though found advancing side by side, are not to be looked upon as being necessarily determined by a common factor or governed by the same developmental laws, but that though undoubtedly bearing an important influence on each other they may quite well be and most likely are the outcome of entirely different processes, the base of the skull developing along lines of its own and quite independent of changes taking place anywhere else.

So much then for a brief survey of the aims and general results of the investigation.

An enquiry into the literature of the subject gave little help, not because the question has been overlooked entirely -- there are abundant observations on the relationship of the growth of the base to the growth of the other parts of the skull - but the investigations recorded are of a more or less general nature and have very little bearing upon

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the subject of the present paper.

While every other part of the skull has at one time or another received the careful attention of the craniologist the base has to a certain extent been neglected. The reason perhaps is not far to seek : as compared with other parts of the skull the base has always been regarded as the most constant part of the skull and the least subject to variation from the type, and whatever work has been done in connection with the base would seem to be mainly in support of this view.

The base offers to the eye no marked and obvious changes at all analogous to those seen else where in the skull, and when it is remembered that it is made up of a series of bones very irregularly put together in a comparatively small and cramped space, it will be seen that the difficulty of investigating the finer changes is very much increased.

A study of the development of the skull appears only to emphasise the view that the base plays but a very secondary part in the evolution of the skull. It is recognised that the main evolution is due to the growth and expansion of the membranous covering bones of the skull, co-incident of course and dependent on the growth of the underlying brain tissue, and that the membranous bones are a new development quite apart from the original premoidial cranium which is represented by the base. The base is

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regarded as being formed in part by the fusion of several vertebral segments, its function being merely to form a support for the rapidly increasing brain with its protecting covering bones: Therefore it is the custom to look upon those parts which are derived from the membranous bones as being the most important and deserving of the greatest consideration. Again, the skull considered ontogenetically shows much the same features as it does when considered phylogenetically. In the developing skull of the embryo every provision is made for the increase and expansion in the brain, not so much by changes in the rudiments of the bones of the base but by changes in the bones of the vault i.e. in those developed in membrane; this is seen in their mode of ossification which takes place from the centre of the membrane bone, an arrangement admirably adapted to allow of the expansion of the rapidly growing brain substance beneath. This is in marked contrast to the conditions obtained in the bones of the base. Even if it be granted that the base takes but a very secondary place in the evolution of the skull, still this admission should not obscure the fact that even if secondary these changes which take place in it may still be important, and the object of this investigation was to note the differences which could be found in different races and to co-relate their relationship with the more obvious changes in the vault. The question to be solved was :

is it possible from an examination of the base of the skull apart from other considerations to form any opinion as regards the place of the skull in the evolutionary scale; or to express it in other words, does the base of the skull change with the changes that take place in the vault and face, and can these changes be at once co-related with each other; does the high, narrow, low-browed, prognathic skull of low capacity belonging to an aboriginal Australian: or the broad, orthognathic, high-browed skull of large capacity of the modern European show any variation in the basal region analogous to the well marked characteristics of the vault.

Let us look at the matter briefly from the point of view of a question in physics, remember however that the physical laws which are applicable to inert matter are very apt to get seriously interfered with when they are applied loosely to living matter. The skull is a structure delicately poised on the top of the vertebral column, obviously then no such wholesale reconstruction of the skull as that necessary to convert the skull of an aboriginal Australian into the skull of a European could take place without very appreciable altering the pre-existing state of affairs. Several things might have happened : either the centre of gravity might be shifted to meet the altered circumstances: or else the change might be brought about by a general readjustment on a system of give and take - a change in one direction

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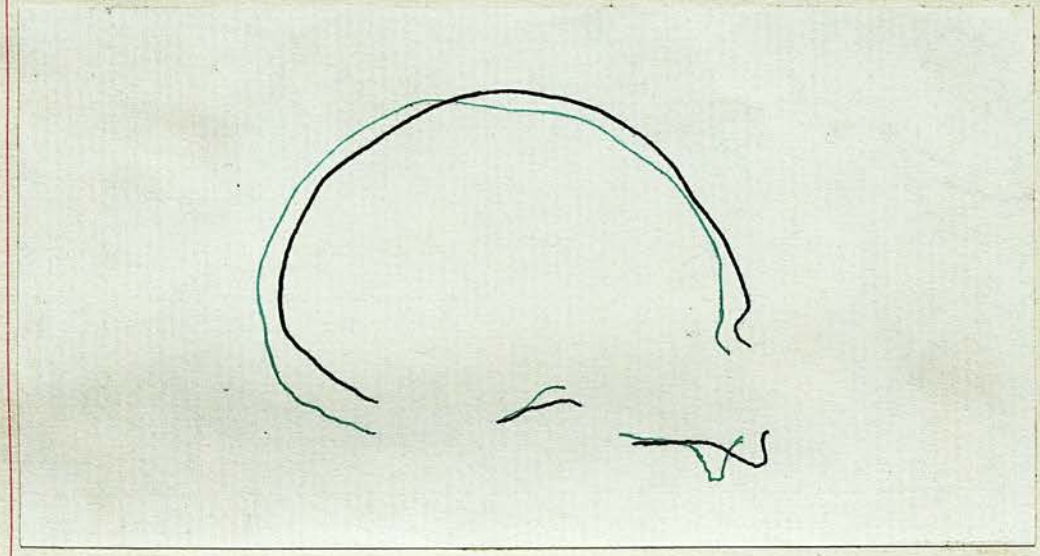
being counterbalanced by a change tending in the opposite direction - the centre of gravity thereby remaining in the same relative position as before; or both these processes may have taken place in the production of the higher from the lower forms.
In figure I is a diagramatic representation of the changes. The black line representing a low type



of skull such as the aboriginal Australian. Now if an increase in growth takes place and a considerable addition is made to the frontal region, other changes must take place somewhere in the skull so as to preserve the natural balance. A corresponding growth might take place at the hinder part to counterbalance the addition in front. If the amount of the projection of the upper and lower jaw were reduced this would also tend in the same direction; and if the cranio facial axis were bent to a more acute angle, thereby making the radius from the centre of gravity shorter, this would also effect the same purpose: finally the centre of gravity might quite well be shifted more anteriorly. We

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know as a matter of fact that most, if not all of these changes do take place and, although in the human skull the differences may be very slight, we can see them clearly illustrated when we trace the evolution of the skull from the form found in the lower animals up to that in man.

That the base does take but a secondary place in the minds of craniologists is evident from the fact that the great majority of the measurements which are used to determine the size, shape and general classification are confined almost entirely to the vault position of the skull, thus the length, breadth and to a lesser extent the height measurements are concerned solely with the dimensions of the cranial cavity and are quite independent of the base; they are measurements depending almost entirely on membranous bones. One can quite see how differences in length and breadth can take place without the active participation of the base in the change, the length being measured from the gabella to the furthest off point on the occipital bone, and the width being measured between the widest part of the parietals. On the other hand however it is equally clear that the length and breadth of the skull have been as readily altered by changes in the base alone.

As the base of the skull is an extensive area and, as the whole is not to be considered in the following account, a definition of what is meant by "base" in

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the following pages is necessary: For the purposes of the present communication the term will be confined as far as possible to that part of the inferior aspect of the cranium between the nasion anteriorly and the basion posteriorly. It includes the following bones, (1) Petro-mastoid, (2) basi-occipital, (3) the lower parts of the sphenoid, (4) the ethmoid; and it will be to the investigation of the relation of these bones to each other that attention will be chiefly directed, i.e. to the base regarded from a developmental rather than a anatomical standpoint. Of the bones mentioned the basi-occipital, the sphenoid and the horizontal plate of the ethmoid go to make up what is known as the cranio-facial axis. It is represented by two lines one horizontal corresponding to the horizontal plate of the ethmoid, the other corresponding to the slope of the basilar parts of the occipital and sphenoid - drawn from the basion and meeting the previous line at the prosphenion. These two lines form an angle open downwards. It is in connection with this angle that we have one long well known fact as regards the base of the skull. This - the spheno-ethmoid angle, as it has been called, has been shown by Huxley to vary considerably in the skulls of various races. In the aboriginal Australian it has an average value of 150°, while in the European it is about 130°. It has therefore suffered a considerable diminution as it is traced from one to the other.

I do not propose to deal with these variations of the spheno ethmoidal angle. They are undoubtedly of the first importance but for their estimation it is necessary that the skulls be sectioned, a process not permissable with the material at my disposal, moreover the work has already been done and the finding of the angle and its variations are proved facts. Such being the case it is obvious that other changes are found to have occurred in the parts adjacent to where this movement has taken place. These changes may be very slight and as they are distributed over a series of bones the formation of which is of a most irregular and uneven kind it may be very difficult if not impossible to determine accurately their nature and extent; for we have not only to deal with what are possibly racial differences but also individual differences between skulls; and when an indiscriminate series of skulls is examined one is struck by the comparatively speaking wide differences that exist in their minute anatomy, not only among skulls of different races but also in a homogenous series of skulls, and even between two bones of the same skulls. Thus it becomes very difficult to decide as to the value of the various differences for the purpose of classification. Still the differences are there and it is interesting to see how far they can be grouped as regards their relationship with the different types of skulls particularly in regard to their place in the evolutionary scale, and if a

sufficient number of skulls be examined certain basal characteristics are found to be associated with certain types of skulls, and though any given characteristic may be worthless as an indication of the comparative position of the skull, nevertheless it may be interesting as a relic of the past or an anticipation of the future as the case may be.

The present investigation does not pretend to be anything more than an attempt to find out from the material at hand if any such thing as racial differences exist in the bones of the base of the human skull. I frankly confess I approached the subject perhaps ill prepared to carry out such an investigation. This much at least could be said, that I did not start with any preconceived ideas about the result, my mind being quite untrained on the subject. Obviously such a state of affairs might be a great advantage and although my lack of a comprehensive knowledge of craniology may have led me into many mistakes and have prevented me from appreciating at its true value much that might have been of the greatest interest and help to me still I hope the result of the work will prove of some interest.

Methods adopted.

The material used in the present work has all been drawn from the collection of skulls in the Anatomical Museum of the University of Edinburgh.

The skulls were taken in groups according to their

races as classified in the Museum catalogue. The number of skulls available in cast groups of course varied very much, there being a large number to choose from some groups while other races were but poorly represented.

The greatest number taken in any one series was sixty and these belonged to the Aboriginal Australian group, while the smallest number was seven. In selecting the others I endeavoured to make the selection as representative as possible.

As regards the sexing of the skulls. No distinction between male and female was made in the Australian skulls, in the rest as far as possible only adult male skulls were used.

In all eighteen different groups of skulls were dealt with :

Scotch.	Papuan.
English.	Morion.
Chinese.	Bush.
Eskimo.	Negro.
North American Indian.	Tasmanian.
Burmese.	New Caledonia.
Malay Peninsula.	Bengali.
Sandwich Islands.	Admirality.
Australian.	Maori.

As regards the methods of investigation each skull was oriented in the Frankfort plane base upwards in any convenient kind of stand. It was then transferred to the dioptograph and a tracing made by

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means of this instrument of the base of the skull as thus seen. It was of course impossible in drawing such an irregular surface to trace everything, as to endeavour to do this would only obscure the picture obtained, it was quite sufficient for the purpose in hand to trace the more important markings. In dealing with a drawing obtained in such a way it must be remembered that it is merely a plan of a most irregular and uneven surface where many of the parts are on quite different levels. As regards the horizontal all measurements taken from it as regards the distance of one point from another must necessarily be the distance in the horizontal plane separating the two points and not the actual distance between them as measured on the skull with a pair of calipers. Of course this refers more particularly to measurements in the longitudinal direction, as it is in this direction that the inequality of the planes is more pronounced. Therefore these measurements cannot be used indiscriminately in comparison with other measurements taken directly from the skull.

After this the skull was taken and fixed in the Wetzels' craniophor so that the sagittal suture was parallel to the horizontal, and a tracing made by means of the perigraph in the sagittal plane of the skull. The various points such as the nasion, basion, bregma, &c. being indicated, as also the points indicating the Frankfort plane. While still in the craniophor the instrument was rotated so that

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the sagittal plane was at right angles to the horizontal, and coronal tracings taken of the vault of the skull at the level of the highest point of the internal auditory meatus and also at the narrowest part of the skull, in the region of the infra temporal crest, the skull being placed in such a position that the basi nasal line formed an angle of 27° with the perpendicular. In thus adopting Professor Thomson's method of orientating the skull I may perhaps as well explain here how we have made use of it. In making the sagital tracings one's only care is that the sagittal plane of the skull shall be parallel to the horizontal and when the tracing is made we make our horizontal on the tracing by drawing a line at 27° to the nasion basion line. As will be seen later it is much more convenient to draw this line representing the constant horizontal in the sagittal tracings, as passing through the nasion instead of the basion. Another line is drawn at right angles to this from the point representing the upper edge of the internal auditory meatus. In making the coronal tracings, with the nasion-basion line at 27° to the perpendicular, the horizontal in the sagittal tracing has now become the perpendicular, and the tracings are all taken at right angles to this perpendicular; so that these coronal tracings can be used in conjunction with the sagittal tracings, because in the sagittal tracings we already have the line drawn at right angles to the horizontal through the meatus, which equally well represents the plane

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at right angles to the perpendicular through the meatus. Consequently if we draw in the middle line in the coronal tracing and impose it on the sagittal tracing so that the middle line of the former coincides with the line at right angles to the horizontal in the latter we are able to determine the position of the plane of the horizontal in the coronal tracing; and having got this we are then in a position to institute a comparison between the coronal tracings obtained from the different groups of skulls.

This may appear involved but a reference to page 16 may make it clearer. Fig. A is the sagittal tracing of a skull; AB = nasion basion line; BC is the line through the basion at 27° to the nasion basion line, otherwise the horizontal; D is the upper edge of the external auditory meatus, and DE the line at right angles to the horizontal D and AF the line at right angles to the horizontal through A. When the skull is placed so that the nasion basion is 27° to the perpendicular, BC becomes the perpendicular and DE represents the plane and position at which the coronal tracing at the level of the upper edge of the external auditory meatus is made. Fig. B is the coronal tracing of the same skull taken at the external auditory meatus with the nasion basion line at 27° to the perpendicular; A

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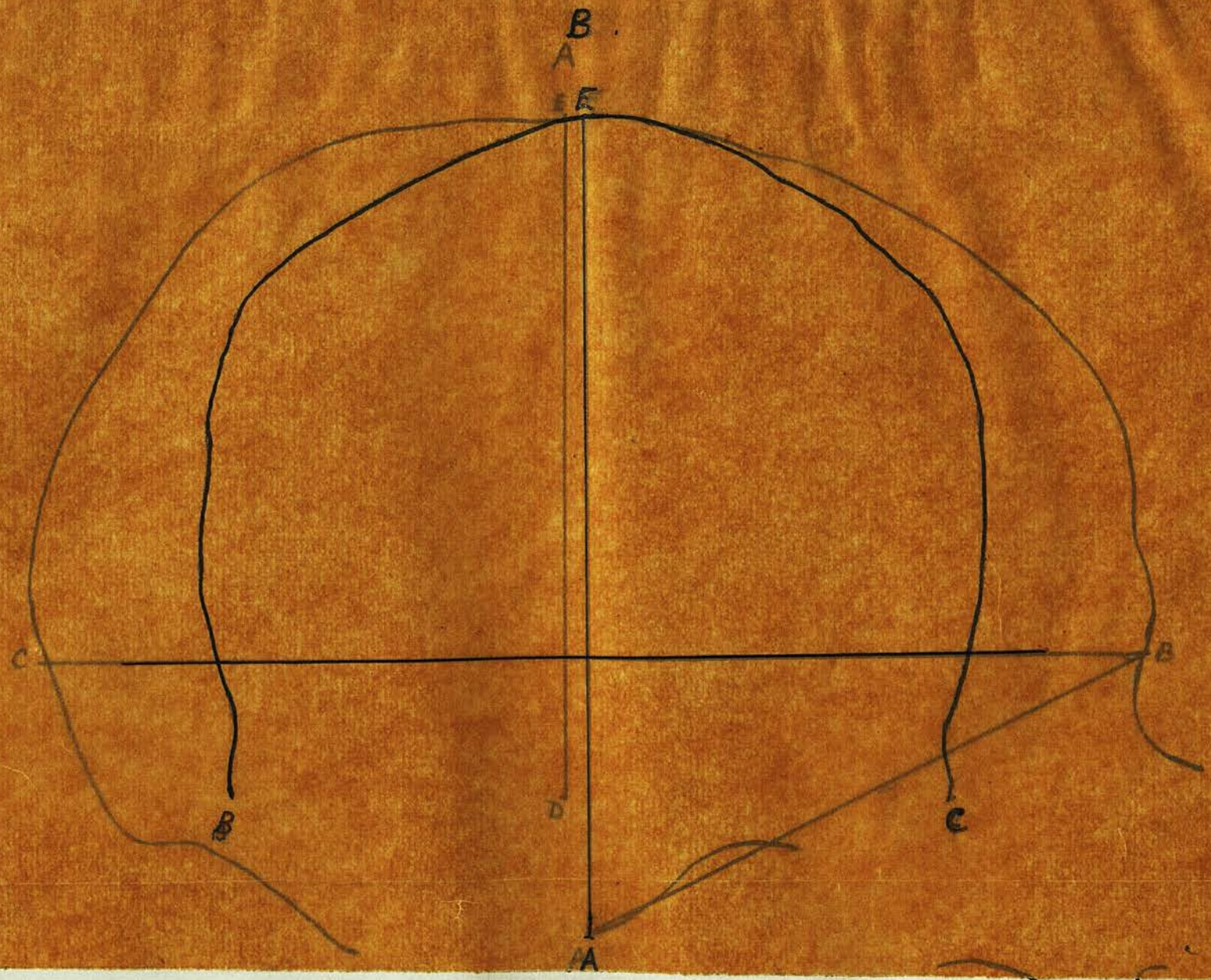
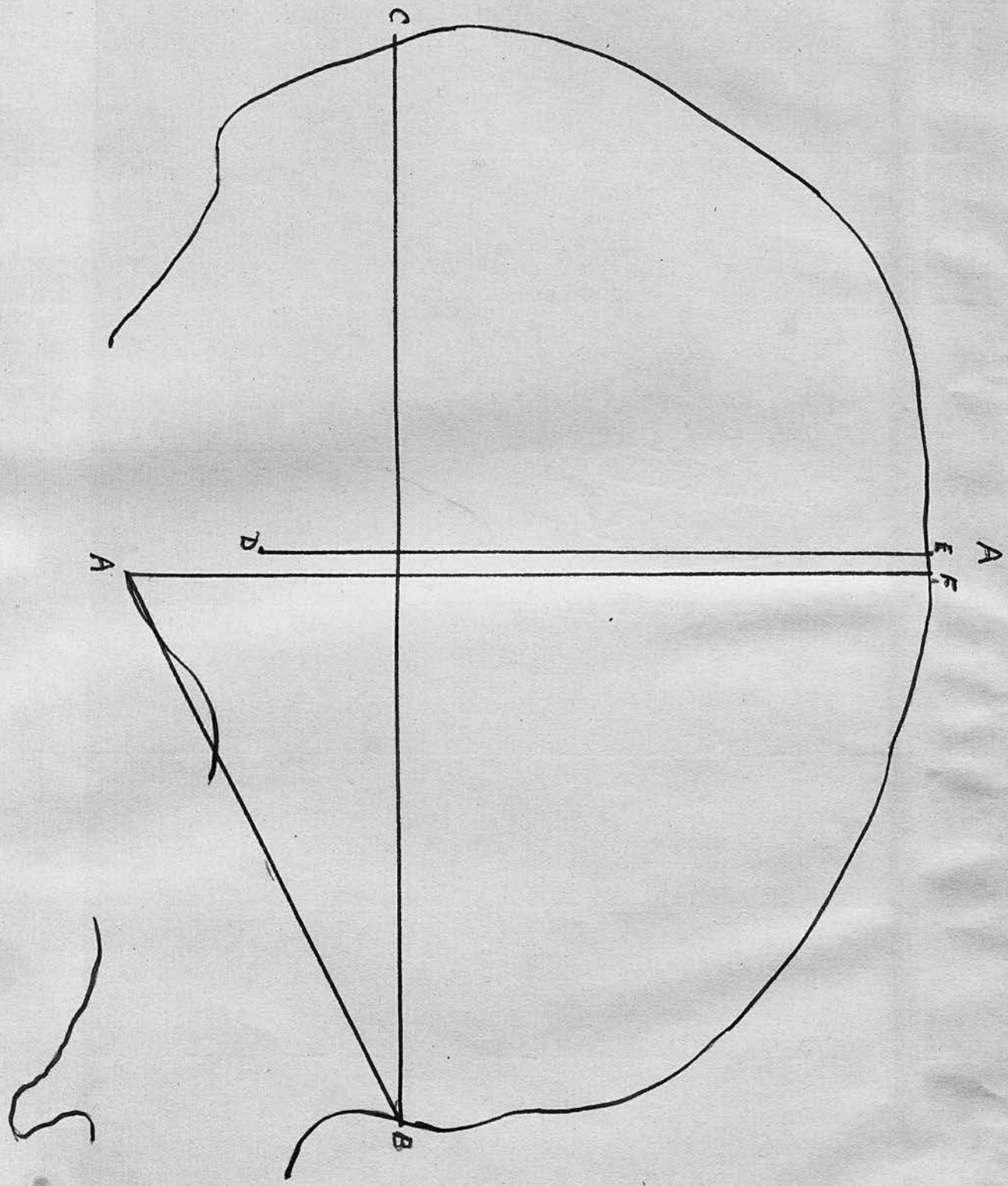


18.

Plate 2

This side to be bound



This Side to be Ground

is the relative position of basion; E is the sagittal suture; AE is the middle line. The tracing BE C then is one made at right angles to the line BC in the sagittal tracing and the level at which it is taken is represented by DE. Superimpose the coronal tracing on the sagittal in such a way that the basion in both cases coincides and the direction of AE coincides with that of AF, the position of the horizontal plane in the coronal tracing is then indicated and can be marked in.

A similar method is carried out in regard to the other coronal tracing.

From all the tracings of the different groups of skulls mean tracings were obtained in the following manner. The original drawings obtained with the perigraph were reproduced on fine transparent paper. In the case of the sagittal tracings nothing more was required but to superimpose them one on the top of another in such a way that the nasion-basion line corresponded in every case, the basion being arbitrarily regarded as the fixed point in that line, this was done on a glass stage so arranged that light from a powerful electric lamp was passed through the tracings; by this means it is possible to obtain a double tracing, one of which the larger corresponds to the tracing of a skull made up of all the maximal measurements and a smaller one which represents a skull made up of all the minimal measurements in the particular group. Between their two extremes all the other tracing were contained. The mean was then drawn between these two extremes and this was regarded as the mean average tracing for that group of skulls.

A similar method was adopted in the coronal tracings, only here it was more difficult owing to the of any constant fined points in the tracings, this was gone over in the manner already outlined, but instead of using the meatus as constant points in the coronal tracings the basion was made use of. This point and also the middle line of the skull were marked in the tracing paper reproduction, and this was

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placed on the sagittal tracing in such a way that the basion in both cases coincided and the middle line in the coronal tracing was parallel to the line at right angles to the horizontal through the meatus. In this was the position of the horizontal can be marked in on the coronal tracing;thus providing us with the necessary constant line for the purposes of superimposing one on the other. Exactly the same method was adopted in the case of the tracing at the narrowest part of the infra temporal ridge.

Finally the following measurements were made on every skull :

Greatest length.
Length from Glabella to Inion.
Greatest length from nasion.
Length from nasion to Inion.
Length from nasion to basion.
Length from nasion to posterior end of vomer.
Length from post. end of vomer to basion.
Greatest breadth.
Breadth as posterior root of Zygoma.
Breadth of base as the narrowest part of great wing of spheroid, i.e. at the spina angularis (breadth at spine).
Width at stylo mastoid foramina.
Width at infra temporal ridge.
Interauricular height.
Basi bregmatic height.
Width of basi occipital at jugular foramen and at narrowest part.

To render the investigation more complete the same measures were adopted with a number of skulls belonging to the higher apes,

4 Gorilla.

4 Orang-outang.

2 Chimpanzee.

A general view of the problem to be dealt with may be gained by a glance at the photographs, figs.1,2,3, 4. F.1 & 2 are scotch skulls, 3 & 4 are Aboriginal Australian. To contrast them fully photographs were taken in three, normae, Lateral, Vertical and Basal, all the photographs being taken under the same conditions. It will be seen at once that each skull shows characteristics which are quite distinctive in each of the three normal – not less so in the basal than in any other; here the characteristic narrowness of the Australian skull being quite easily appreciated, being distinctly long and narrow as compared with the Scotch skull. But it may be said that this difference may be one of appearance only due to the shape of the skull as a whole and more particularly to the presence in one of a more pronounced degree of prognathism than in the other, which by the greater slope of the pterygoid processes and by the forward projection of the upper jaw may cause the base to appear longer and narrower than it really is. It may also be objected that these skulls have been selected as representing extremes in their own particular groups and are not typical of the groups to which they belong, even if this were so it

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Fig. I.

Lateral view of Scotch Skull.

Fig. 2.

Lateral View of Scotch Skull.

Fig. 3.

Lateral view of Australian skull.

Fig. 4.

Lateral view of Australian skull.

Fig. 1a.

Vertical aspect of Scotch skull.

Fig. 2a.

Vertical aspect of Sexton's case

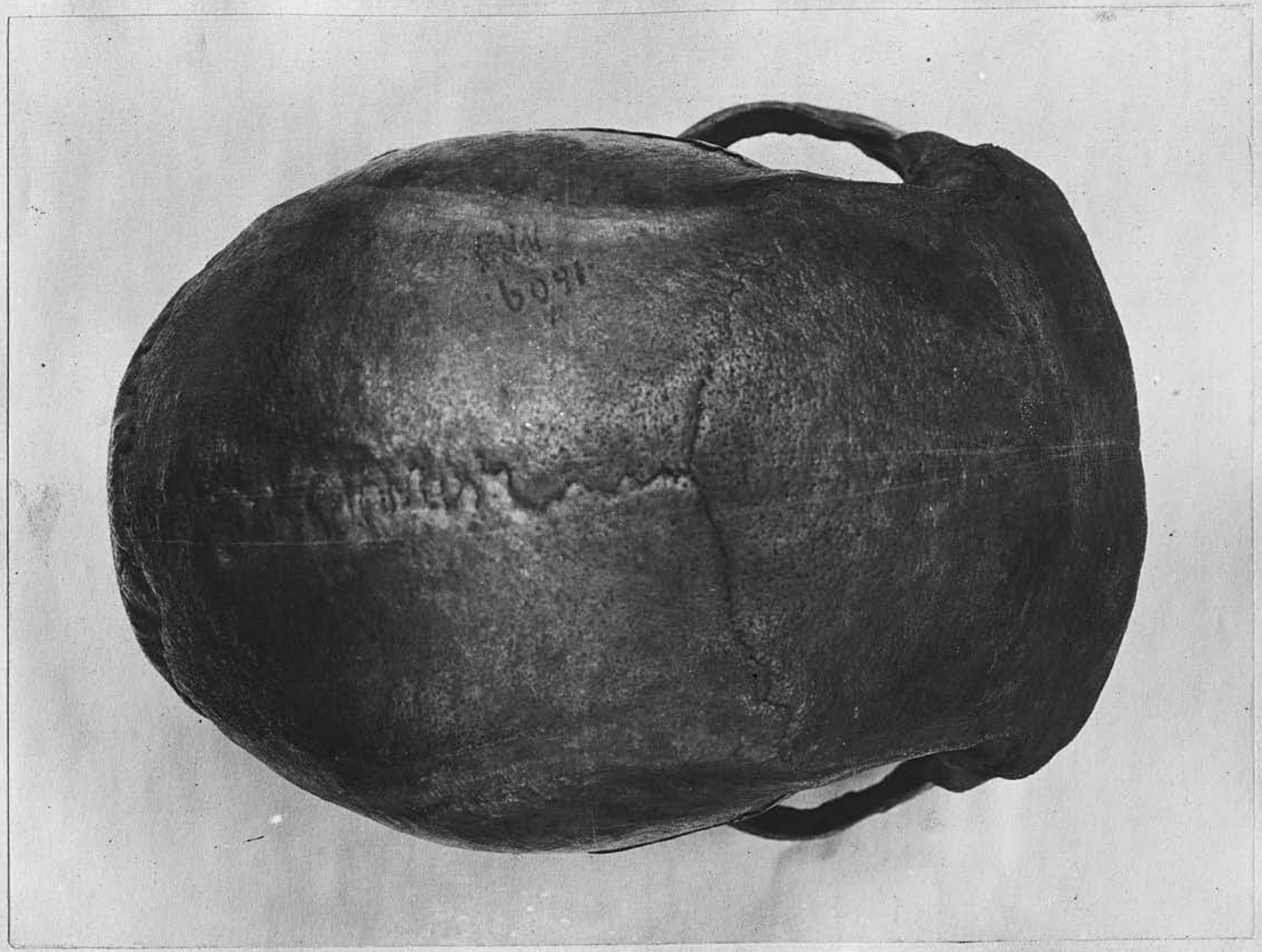

Fig. 3a.

Vertical aspect of Australian Skull.

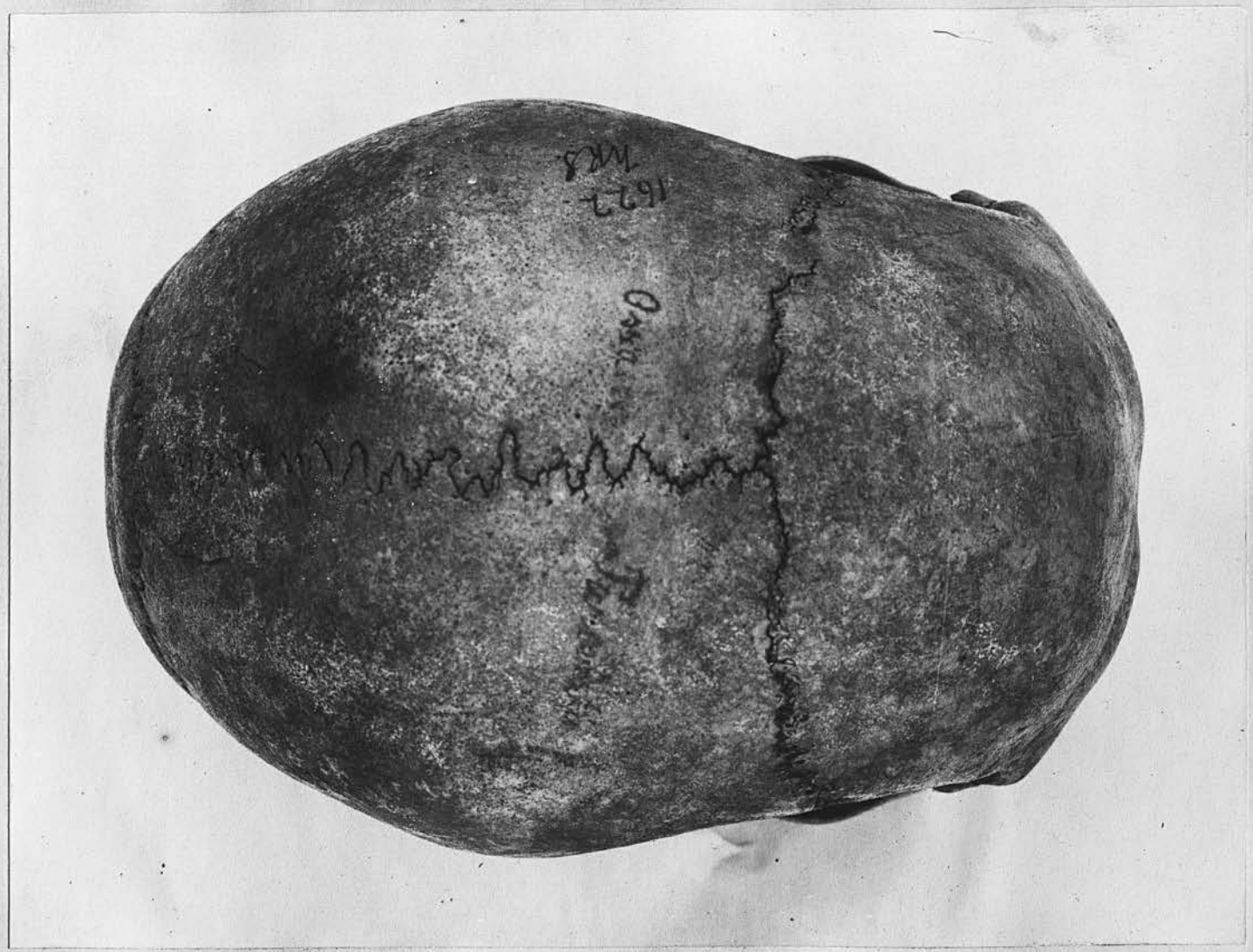

Fig. 4a.

Vertical aspect of Australian Skull.

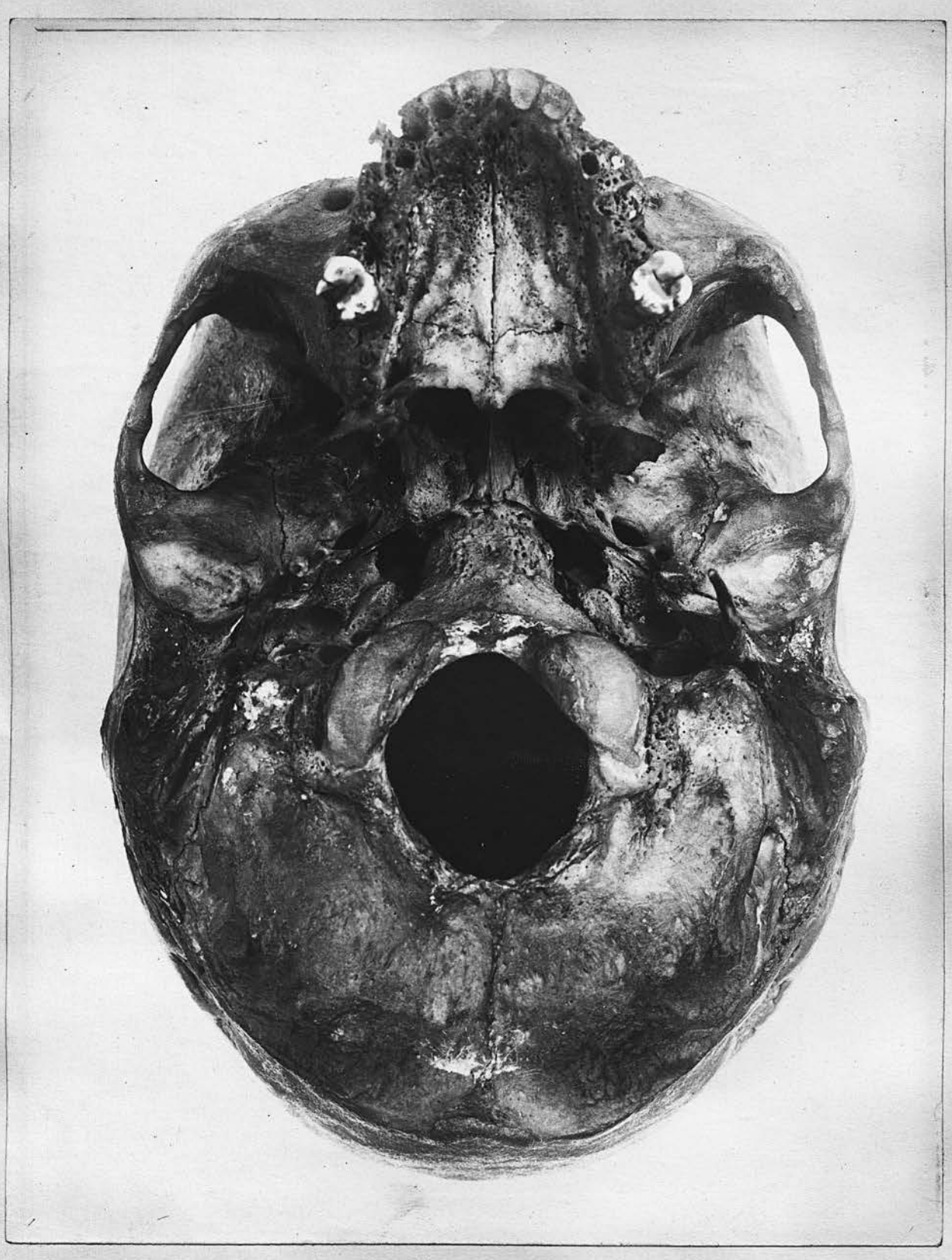

Fig. 14.
Basal aspect of Scotch skull.

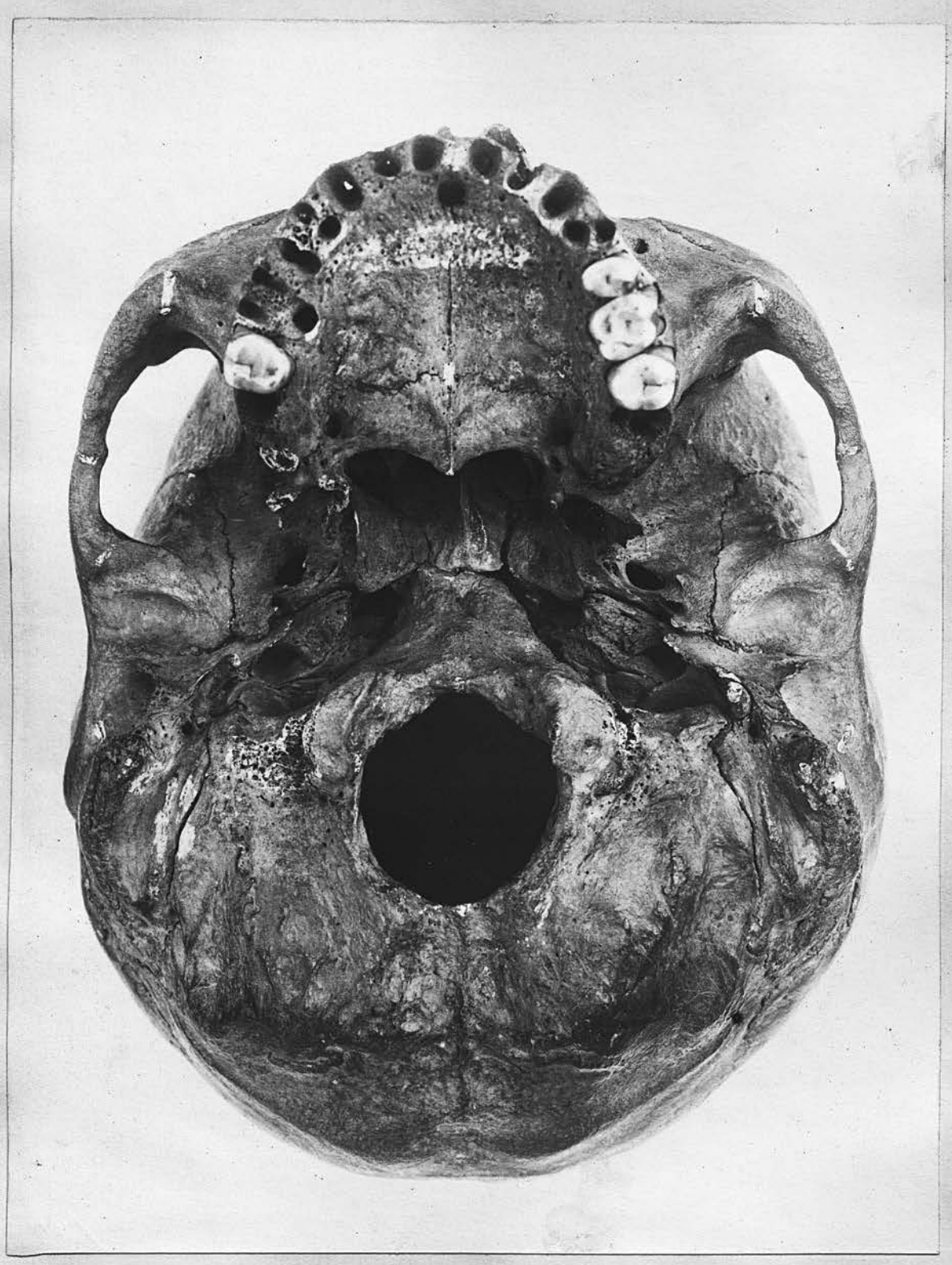

Fig. 22.

Basal aspect of Scotch skull.

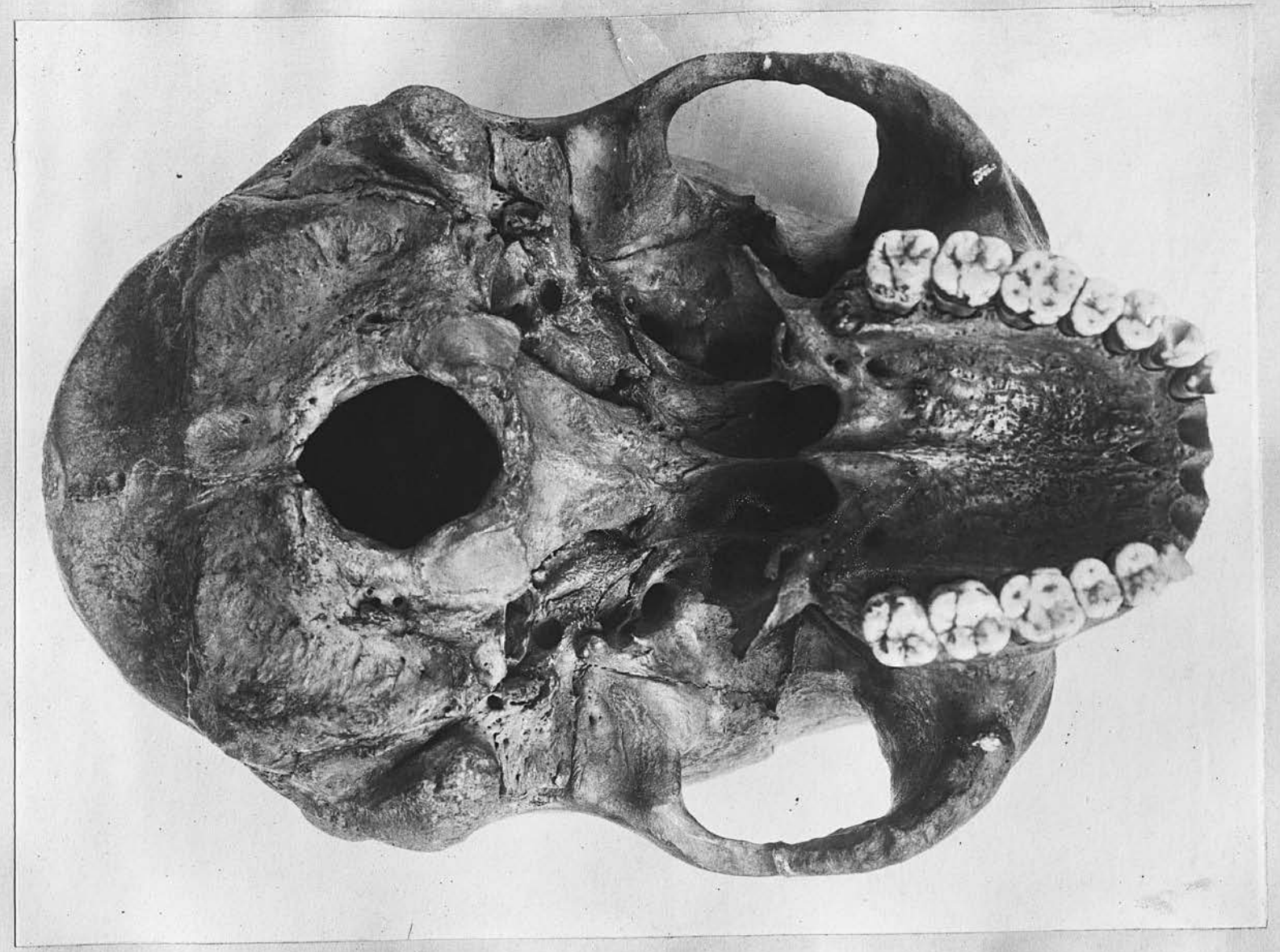

Fig. 31.

Basal aspect of Australian skull.

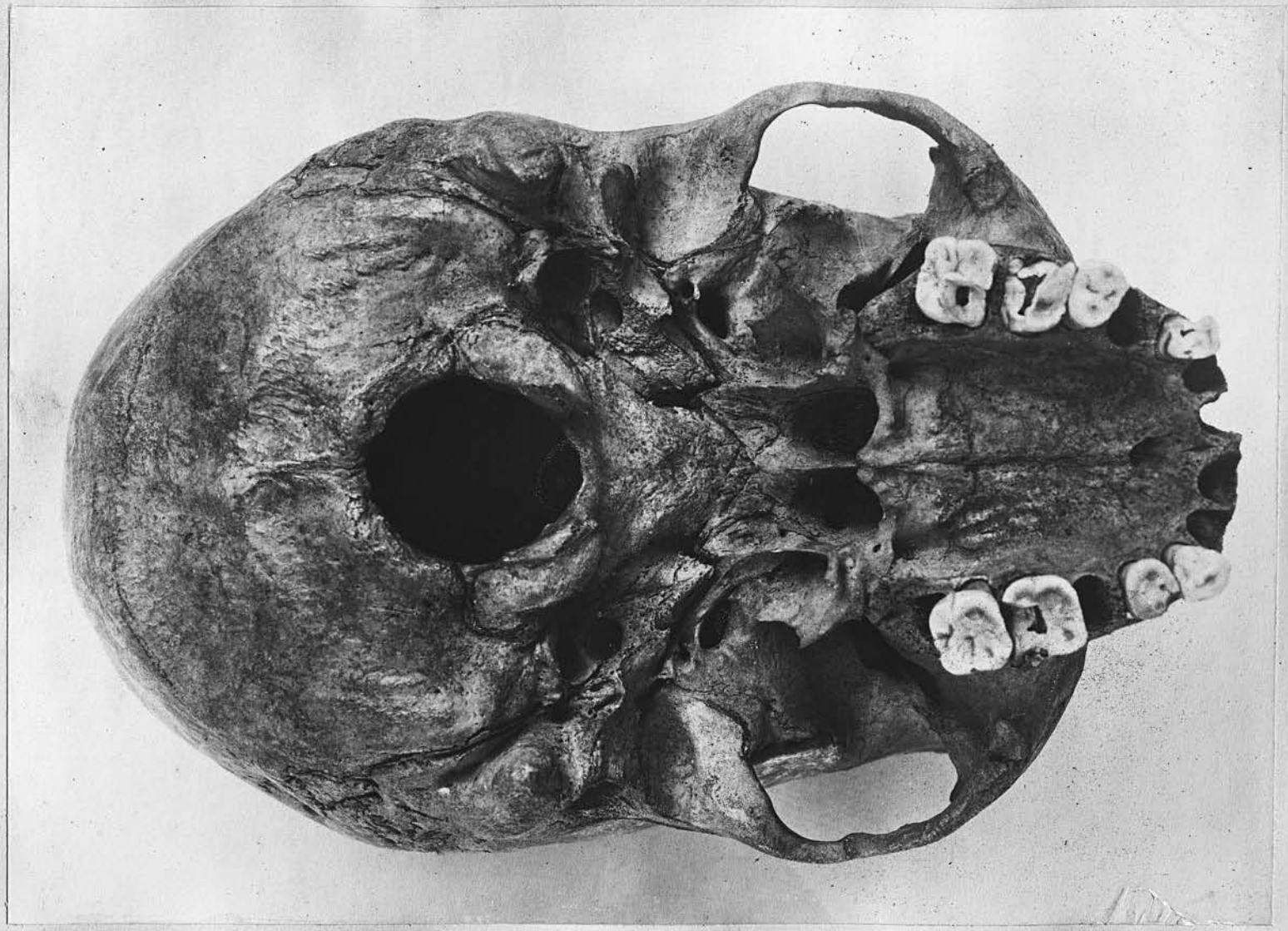

Fig. 42.

Basal aspect of Australian skull.

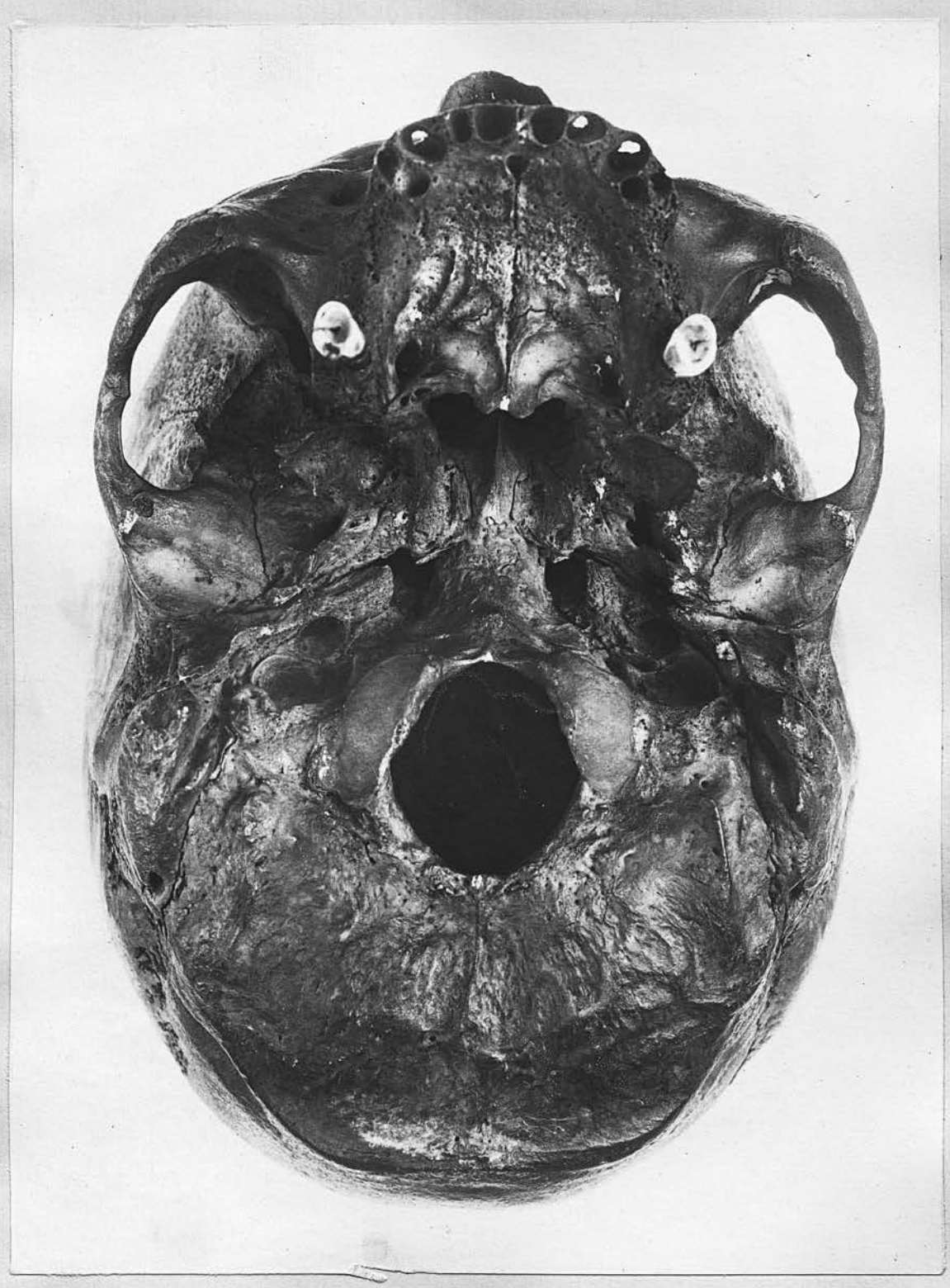

Fig. 5.

Basal aspect of Soster skull.

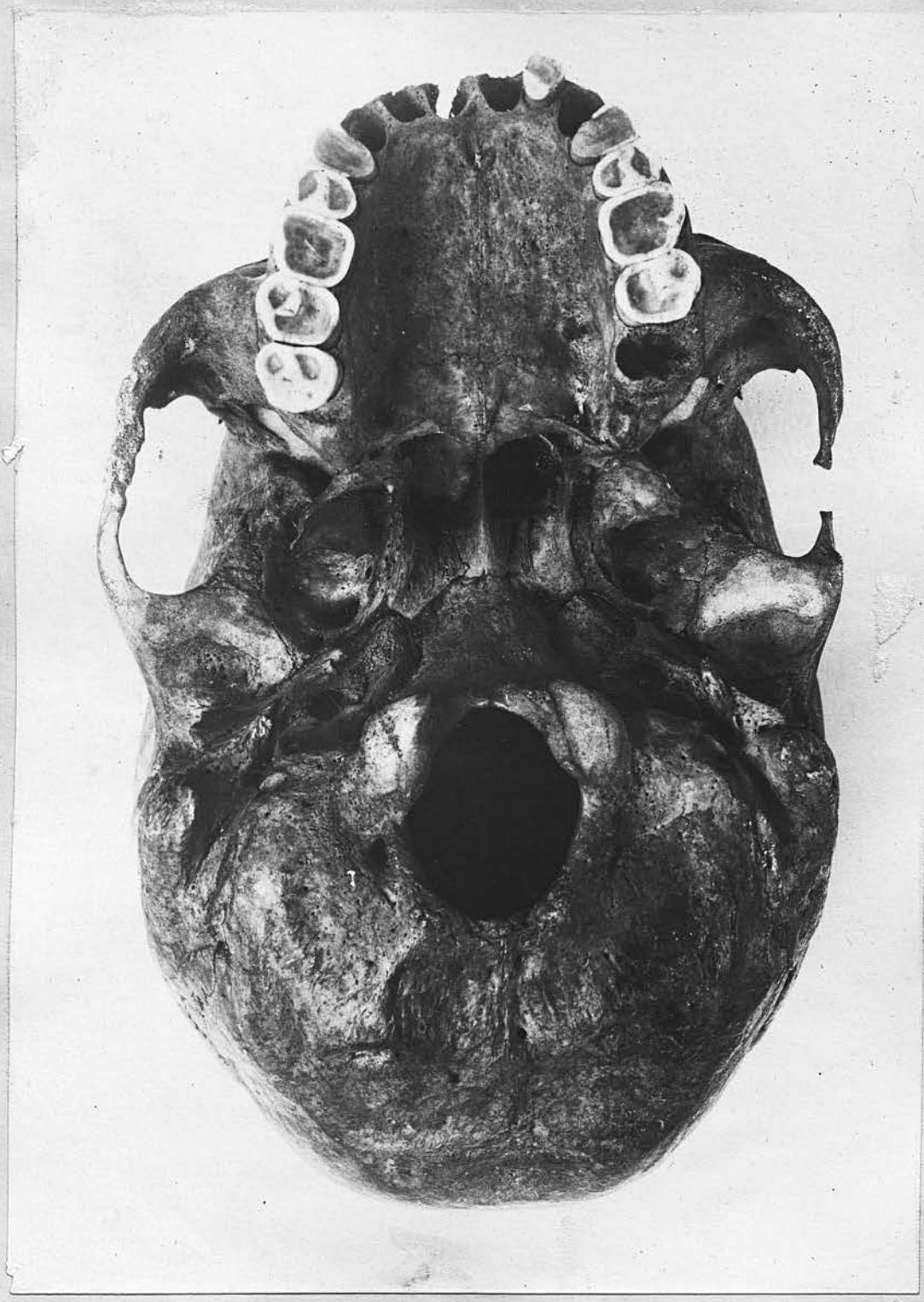

Fig. 6

Basal aspect of Australian skull.

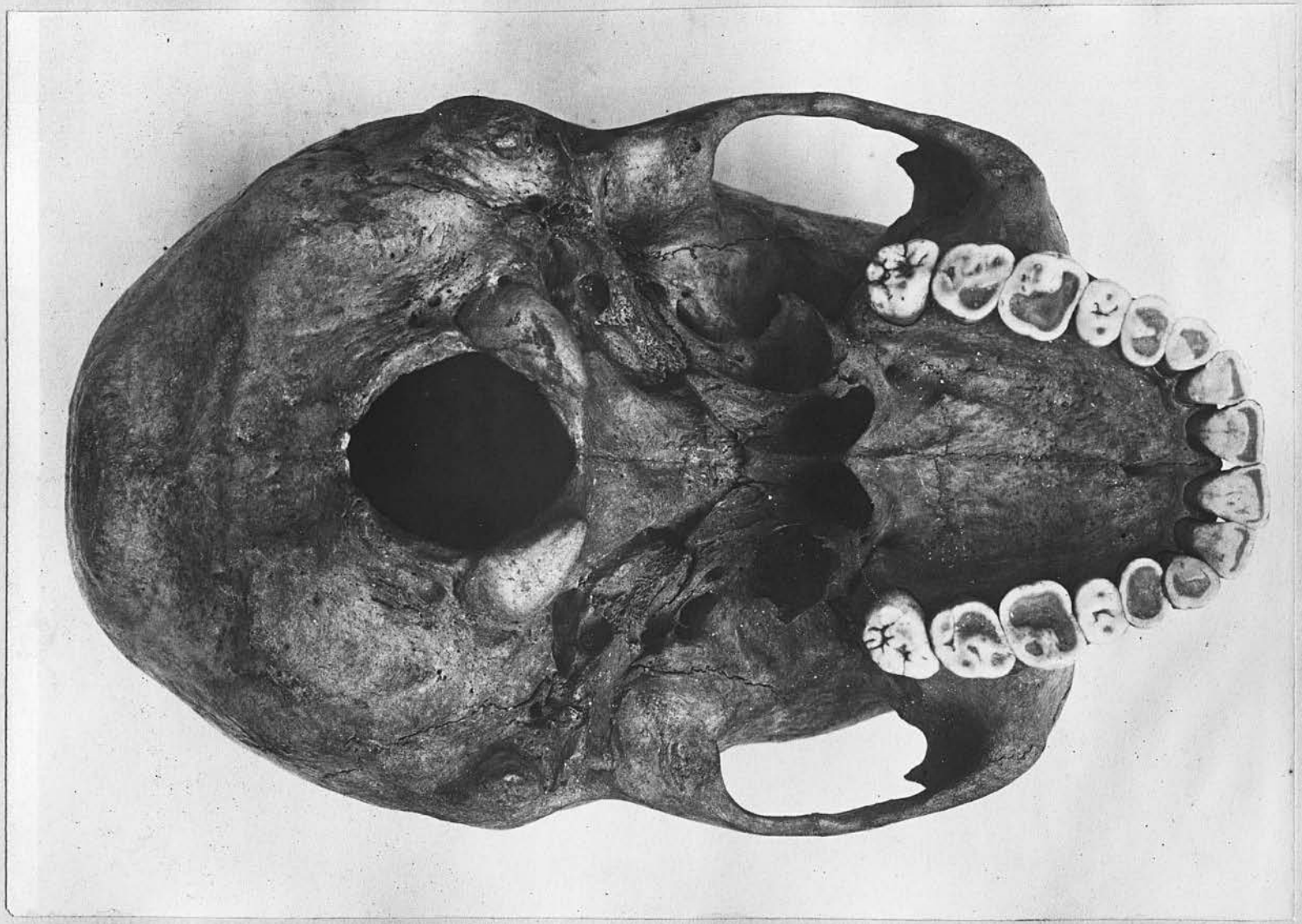

Fig. 7.

Basal aspect of Australian Skull.

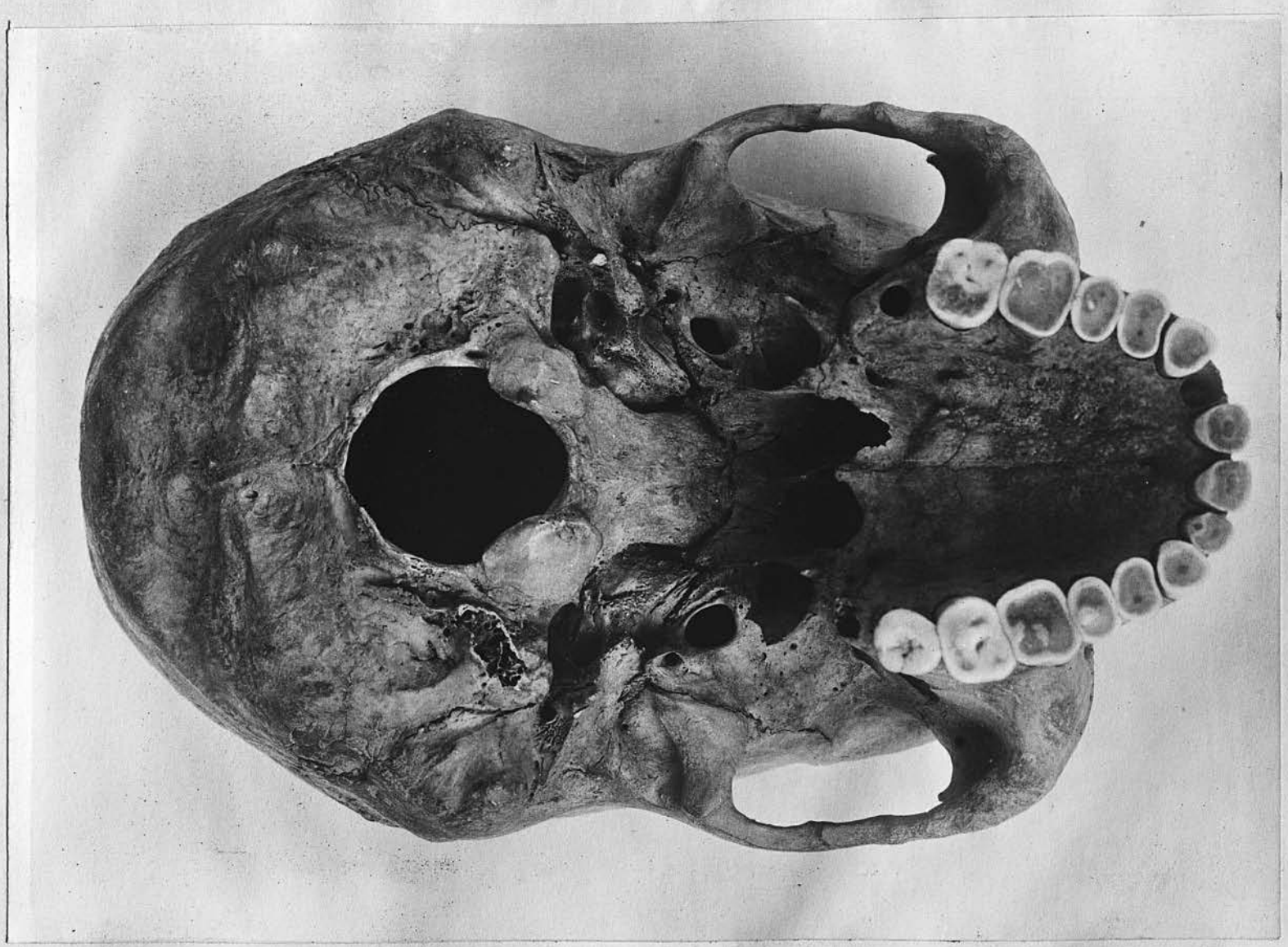

Fig. 8

Basal aspect of Australian skull.

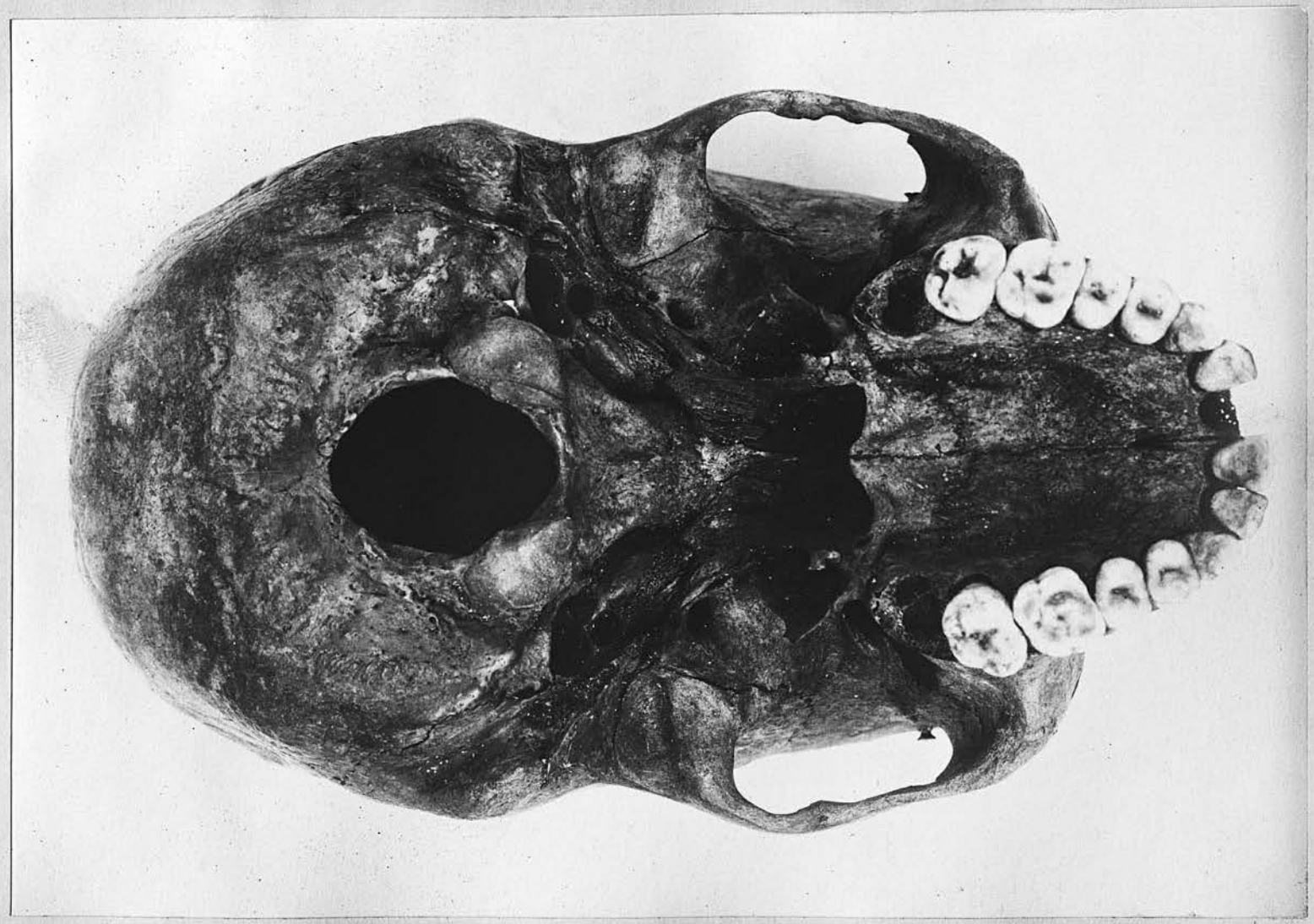

Fig. 9.

Basal aspect of Australian Skull

will serve equally well for the purpose of bringing out the manner in which these two types of skulls differ from each other; besides if the appearances found elsewhere in the skull are essentially typical, then we should equally so regard the appearances seen in the base in the same light.

Confining attention to the part described above as the base it is obvious that quite an appreciable difference exists in the width - the scotch skull being much broader. Perhaps the most noticeable features however are the differences that exist in the lower surfaces of the petrous temporal and the relation which this bone bears to the others. The characteristic of the Australian skull is the compactness and regularity in the moulding together of the boney elements, and the close relationship which the petrous temporal bears to the other bones surrounding it, i.e. the sphenoid and the basi-occipital. This is particularly well seen in the region of the foramen Lacerum which is reduced to a minimum by the close approximation of the apex of the petrous to the angle which is formed by the sphenoid and the basi occipital, in fact the apex actually runs right up on to the base of the pterygoid process, the petrous temporal fitting very accurately into the space between the sphenoid and occipital, with a minimun amount of free space in between. The Scottish skull offers a marked contrast, there is much less compactness and regularity in the fitting together of the various elements constituting the base. The apex of the petrous is not developed to any such extent

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in the Australian , the bone ending in a blunt irregular extremity and falling considerably short of the base of the pterygoid process,leaving a very wide foramen lacerum which allows of free communication between the interior of the skull and the outside, a condition very different from that found in the Australian skull. The same point is also well illustrated in other particulars of the base. In the Australian the base is made much more strongly and more massively, with more attention to detail and to the more complete rounding off of all corners and the filling up with bone of all the available space between itself and the surrounding bones than in the Scotch; further all canals and foramina tend to be sharply marked off with well formed and complete edges. The Scotch skull looks like a half finished product in some respects: it lacks the completeness of detail of the Australian. In the Australian only the lower opening of the carotid canal can be seen. In the Scotch it lies practically visible for the whole length, due to the fact that the lower margins are much wider and less rounded off than in the other, and in the medial three quarters of its length the floor is quite wanting on account of the absence of the lower part of the apex as mentioned before. The bone itself is formed much less massively and less strongly than in the Australian. Contrasting the conditions found in the two skulls it might be said that the Australian shows a more preponderancy of bone

over /

over openings and the Scotch shows a preponderancy of opening over bone. The tympanic bone in both skulls also shares the general characteristic just described, and in addition it will be seen that there is decidedly more of it in the Australian than in the Scotch skull. The breadth of it, as measured roughly from the stylo mastoid foramen to the outer edge of the external auditory meatus being greater in the former than in the latter. The outer free edge of the tympanic plate in the Scotch has the appearance of being cut away, so that on looking at it one can see very much more of the roof of the external auditory meatus in the Scotch than in the Australian. In addition it is much thinner and much less massive than in the Australian, the lower free margin is represented as a thin sharp edge along the whole length of the bone while in the Australian it forms in contrast a thick, blunted, ill defined edge. This of course might at once be explained as being a great part due to the great increase in the development of the styloid process in the Scotch skull, the greater length and size of the process requiring much more support than the shorter Australian one, in consequence of which the vaginal process has shared in the increase so as to provide the necessary extra buttressing. There are many other points of differences in the skull base, such as differences in the formation of glenoid fossa, mastoid process, condyles, foramen magnum, &c., these have been all recognised as possessing characteristics in various skulls, but they do not properly come into the

scope /

scope of the present work.

Another point about the under surface of the petrous is that in the majority of cases it can quite readily be divided into three distinct areas by more or less well defined lines. The first or anterior of these lines runs from the vaginal process along the under surface of the bone and in the direction of its long axis and ends in the apex. The second runs parallel to the first from the medial edge of the lower opening of the carotid canal and loses itself on the medial border of the bone: while a third one marks the postero medial edge of the bone and joins the lower lip of the grove which holds the inferior petronal sinus. These ridges divide up the lower surface of the bone into three areas :

1. An area antero-lateral between the antero-lateral border and the first ridge.

2. An area intermediate between the first ridge and the second.

3. An area postero-lateral between the second ridge and the postero-internal border of the bone.

The anterior area enters into the formation of the grove for the Eustachian tube and gives origin to the tensor tympani muscle. From the second area arises the ~~tensor~~ palati, and to it as well as to the medial area is attached the dense fibrous tissue which fills up the cleft between the petrous and the basi-occipital. The markings are much more complete and definite in the Australian than in the Scotch skull. In the

Australian /

Australian the antero-lateral area is sharply defined from the intermediate part by the well marked ridge and is of much greater extent than in the Scotch, where the distinction between the two parts is but faintly defined . Further it is made up of much stronger bone, and while in the Scotch deficiencies in it expose the interior of the carotid canal, such deficiences are not as a rule present in the Australian, where the antero-lateral wall of the canal is complete throughout its whole length. The intermediate part forms the floor of the carotid canal and may be described as roughly quadrilateral bounded antero-laterally and postero-medially by the two parallel ridges, antero-medially by the lower margin of the apex of the bone and postero-laterally by the lower opening of the carotid canal. In the Australian this area is much more complete and of greater extent than in the Scotch,in which particularly the antero-medial portion may be altogether deficient. In both cases the developmental elements of the bone corresponding to the petrous and tympanic part can usually be made out but with this difference that in the Australian the fusion between the two parts is much more complete than in the Scotch; the result being that in the Scotch skull we have a much more irregular margin guarding the entrance to the carotid canal, so that whilst in the Australian nothing can be seen of the carotid canal from below save the lower openings, in the Scotch the greater part of the interior of the canal is visible. The points mentioned cannot be

well /

well defined by measurements nor are they readily expressed in any graphic manner, still the points of difference are very obvious and are easily discerned in the accompanying photographs where they are so marked that they define at once the two types of skulls. Let it be admitted that the skulls chosen for comparison are extreme examples; even so, if a large enough number of skulls from different races are examined transitional stages between the two types are to be found, for not only among different races but also among members of the same race skulls may be found in which the inferior surface of the temporal bone is very definitely of the form described above as belonging to the Australian type, while others present the features of the opposite type. Nevertheless among the Australian and other low types of skulls the configuration described as characteristic of the Australian is much more frequently met with than in skulls of the other higher races , and the Scotch type is met with much more frequently in the higher than in the lower type of skull. Therefore the differences noted may be looked upon to a certain extent as racial differences. They may be summed up as follows :-

1. In the lower skulls the inferior surface of the petrous temporal tends to be made up on a more complete solid and finished pattern. It tends to be more definitely demarcated into three areas by two well defined parallel lines, and antero lateral and a postero-medial.

2. The lower margin of the apex of the petrous

tends /

tends to be accentuated and to run close up to the base of the pterygoid process thus reducing the foramen lacerum to the smallest dimensions.

3. The margins of the foramina tend to be complete and well formed.

4. The whole general tendency is towards strength and solidity.

In the higher skulls on the other hand the lower aspect of the temporal bone tends to be less complete and finished. The demarcation into three areas is not so definite as in the lower type. It rarely ends in a definite well formed apex but has a blunt irregular termination coming considerably short of the base of the ptergoid process, thus leaving a wide foramen lacerum; the carotid canal tends to be shorter and less complete; the tympanic bone is comparatively thinner and weaker and the whole appearance is one of a decrease in the amount of the boney substance with a corresponding increase in the size and extent of the various foramina.

Individually these points have little importance but taken collectively they form a whole the importance of which becomes more evident when used as a means of comparison between human skulls and skulls belonging to the higher apes. Figs. 10, 11, 12 are photographs of the bases of the skulls of a gorilla and of a chimpanzee. An examination of these shows that the characteristics of the temporal region are massiveness and strength of formation; the large

boney /

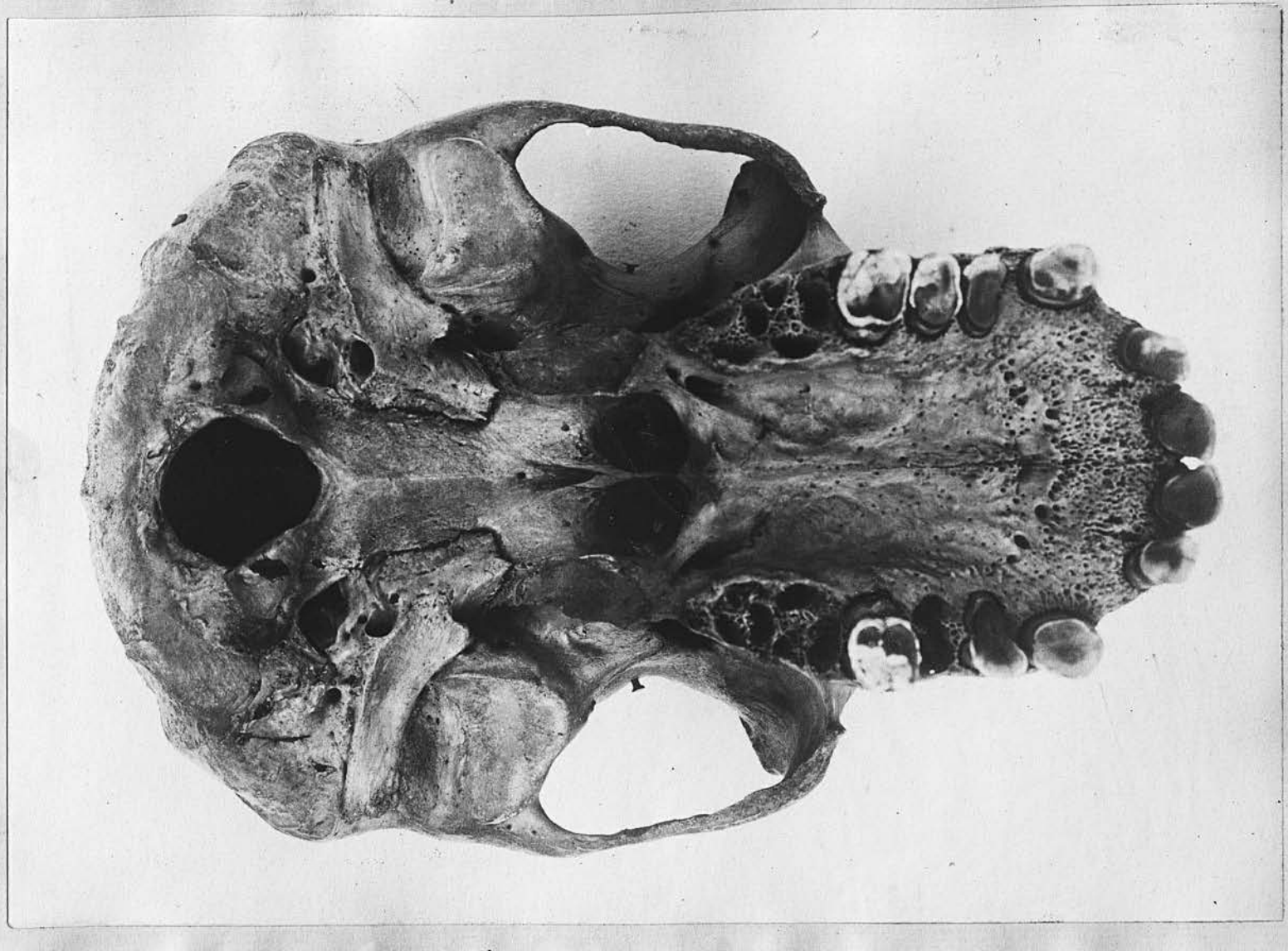


Fig. 10.

Basal aspect of skull of Chimpanzee

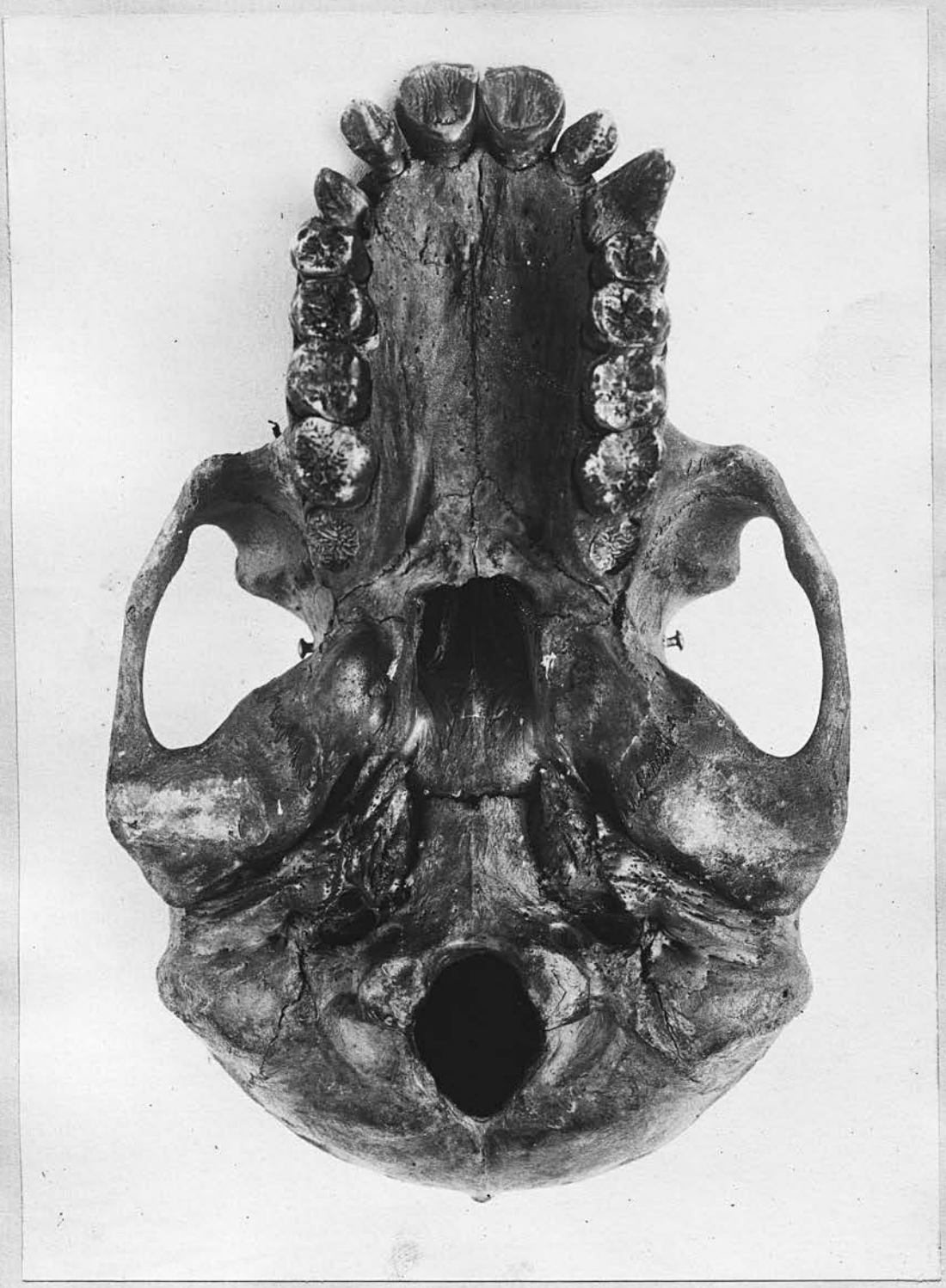


Fig. 11.

Basal aspect of the skull of an Orang.

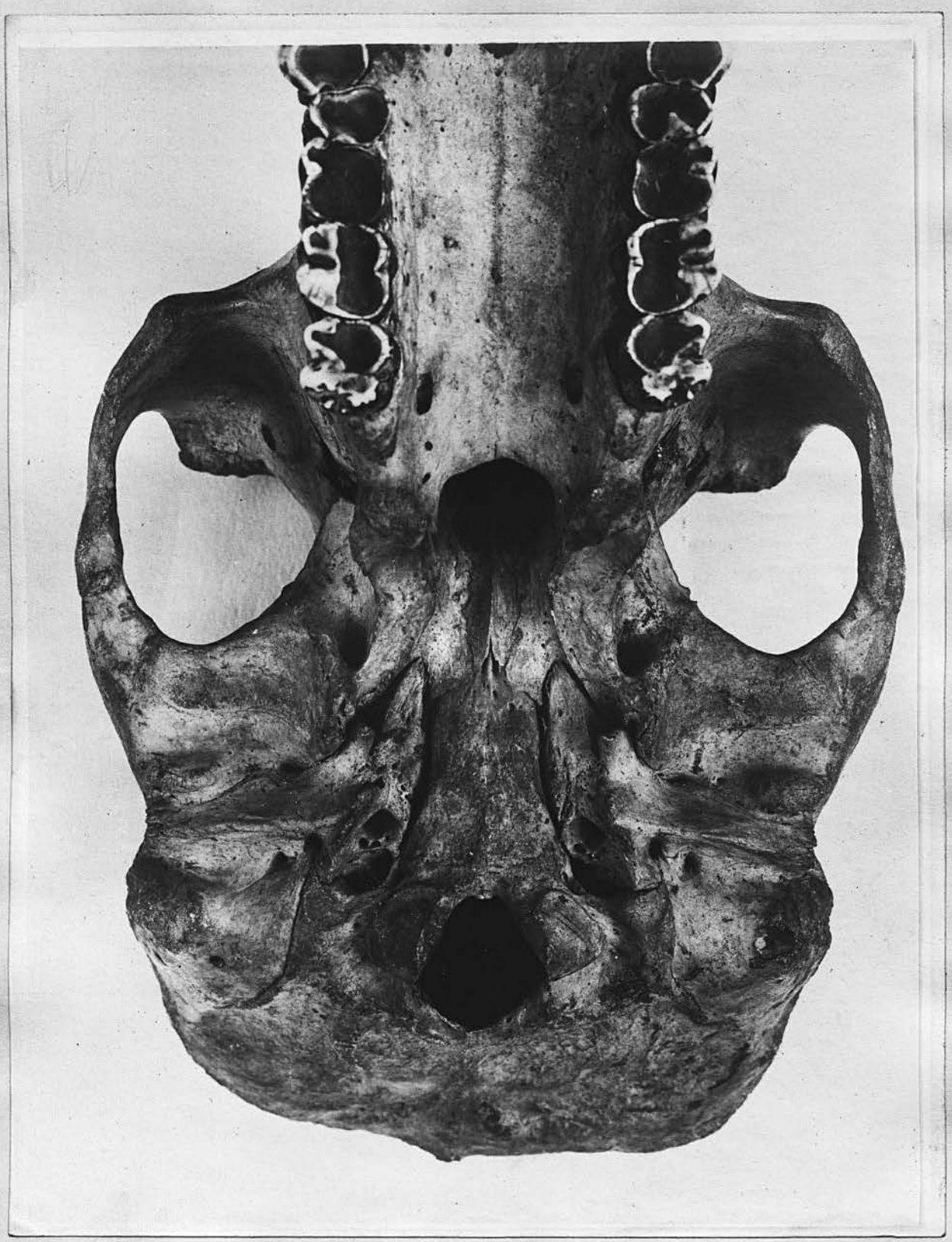


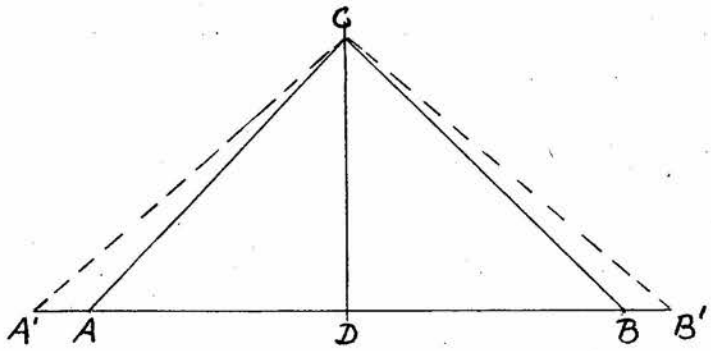
Fig. 12.
Basal aspect of the skull of a Gorilla

boney protuberances which are present in different parts; the absence of small, slight irregularities; the completeness and comparative smallness of the foramina, the length of the tympani part; the well developed apex which runs right up on to the posterior part of the sphenoid; the obliteration of the foramen lacerum; the ill developed vaginal process, and the nature of the lower edge of the tympanic plate. Again another striking difference between these skulls and the human is seen in the angle at which the petrous part of the temporal is set to the rest of the bone. In the Chimpanzee and Gorilla this angle approaches a right angle judging from a mere inspection of the photograph. In the Australian and Scotch it has widened out considerably, the importance of this however will be more fully dealt with later on. From this it must be seen that the points which have been referred to point to the occurrence of an evolutionary process. It is hardly necessary to say however that the distance separating the type found in the anthropoid ape from that found in the lowest human is infinitely greater than that which separates the extremes of the human skull, and although either type may occur indiscriminately in any collection of skulls from one human race the extreme form met with in the ape is never found in its entirety in any human skull.

Turning again to the general characters of the base, in the two types as mentioned before, one of the most distinguishing features is the difference in the

breadth /

breadth of the base in the Scotch as compared with the Australian. The Australian is long and narrow, the Scotch short and broad. This being so the question naturally arises how this is brought about and in what way are the various bones affected ? If the temporal bone be taken and its position noted in the base of the skull, its long axis will be seen to be running antero-medially, but the angle formed between the temporal bone and the median plane varies in different types of skulls, and it might be anticipated that the change in the angulation would be associated with the evolution of the skull; for in passing from the lower to the higher the base becomes broader while the length is not affected to the same extent. The increased width therefore cannot be accounted for by a general increase in the growth of the skull and growth must have taken place in one direction more than another, possibly such changes in growth may have been associated with changes in the relative position of the bones to each other, and if this is the case the bone which should be most affected by the change on account of the peculiar position it occupies, is the temporal bone. In an average European skull the axis of the petrous part of the temporal bone taken from the stylo mastoid foramen to the apex meets the corresponding axis of the opposite side in the median plane at an angle of about 90°. The convergence of the axis in the median plane may be represented by the following figure.



If now the base be widened from AB to A'B' other things remaining equal, the angle between the converging lines will become wider. Of course such a figure is not intended to represent the changes that take place in the base of the skull, it only serves to illustrate the point under consideration.

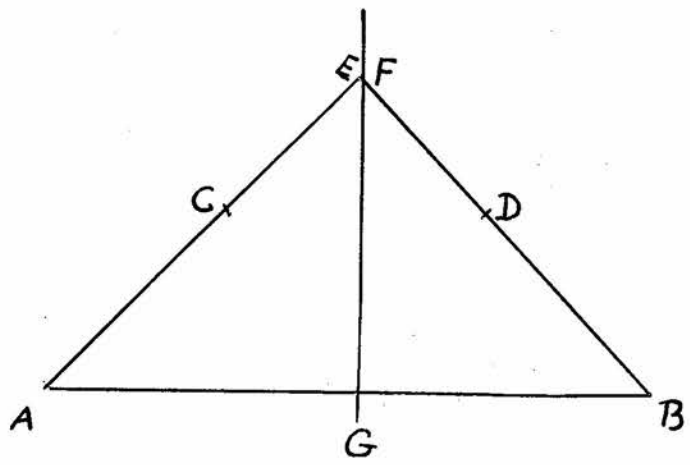
It has now to be decided whether or not any such alteration of position is recognisable in the transition from the skulls with narrower to those with broader bases, and here the question dealt with is one which can be more or less satisfactorily settled by definite measurement and graphic representations.

The methods adopted in investigating the point was as follows: After the base of the skull had been drawn as described by means of the dioptograph, the following points were made use of : The two stylo mastoid foramina, the two apices of the petrous temporal and the middle line of the skull. Those points were then traced through to another sheet of paper and a figure constructed for each skull, the stylo-mastoid foramina were joined by a base line, and from the centre a perpendicular was projected to represent the median plane, then the axes of the temporal parts of the temporal bone were drawn in and produced till

they /

they cut the middle line. It might have been much more convenient to have regarded the middle line of the skull as the perpendicular from the middle point of the base line, but as no two sides of the skull are absolutely symmetrical it was thought better to keep to the middle line between the stylo-mastoid foramina. Similar figures were constructed for all the skulls in the series, the various distances were calculated out, i.e. the distance between the stylo mastoid foramina, the length of the petrous, the distance of the stylo mastoid foramen from the middle line along the axis of the petrous, and the length of the middle line from the middle point of the base line to where the axis of the petrous portion of the temporal cut it.

The following figure gives an illustration of the various measurements taken :-



AB = Stylo mastoid foramina.

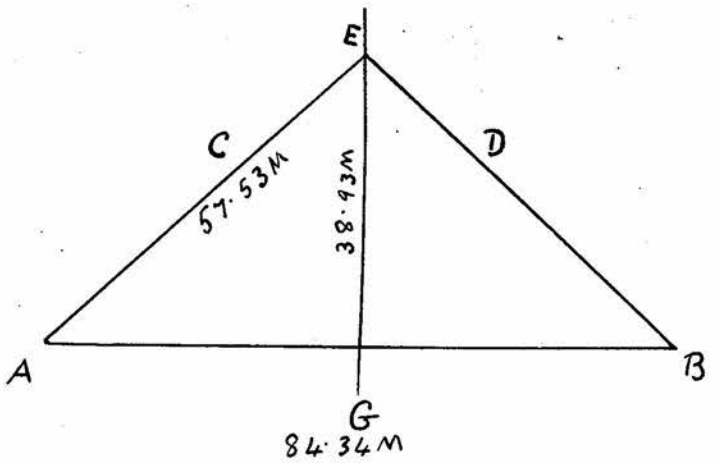
GE = Middle line.

AC = Length of petrous.

AE & BF = Axis of petrous.

As, on account of the asymetry in the bones, measurements taken on both sides of the skull do not correspond, in the final measurements the average of the measurements on the two sides was taken and this was regarded as the measurement, also as the middle line of the skull passed within a millimetre or less of the middle point of the base line this was neglected and the middle line of the skull was looked upon as passing through the middle point of the base line.

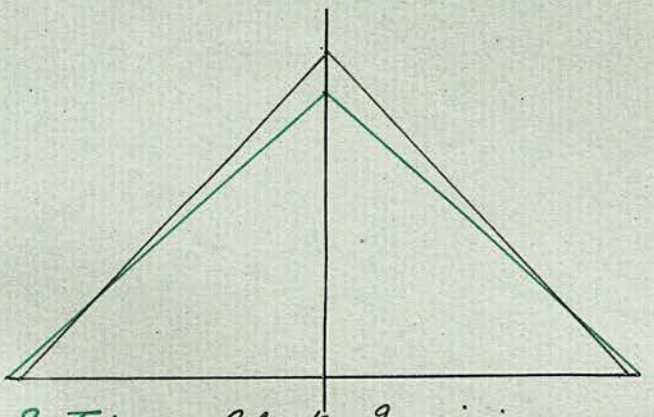
Obviously for our purpose the two chief measurements are the breadth between the stylo mastoid foramen and the length of the middle line, because if we know these we have then the means of measuring the angle made by the axes and the middle line.
Turning to the table on page 54 we find the base line varies from 76 m. to 87 m. and the middle line from 37 m. to 43 m. between these extremes all the others are grouped. The simplest method to bring out the differences between the skulls is obviously to construct a triangle with sides equal to the various measurements found in the skulls, i.e. the base of the triangle being equal to the breadth between the stylo-mastoid foramina, the height being equal to the length of the middle line from the middle point of the base line to the point where the axes of the petrous temporals cut it, and the sides being equal to the lines drawn from the stylo mastoid foramina to their intersection, i.e. the axes. Thus the triangle representing the Scotch skull would be :-



	Base line or breadth between Stylo mastoid foramina	Half of Base line	Length of petrous	Length of axis of petrous	Length of Middle line	Cephalic Index
	m.	m.	m.	m.	m.	m.
English	83.3	41.65	32.55	55.95	38.1	76.94
Scotch	84.34	42.17	32.79	57.53	38.93	78.17
Eskimo	87.04	43.52	36.08	60.33	42.94	73.5
Moriori	82.6	41.3	35.08	60.76	43.55	75.51
Maori	82.3	41.15	36.21	58.61	41.67	75
Tasmanian	79.3	39.65	33.14	56.42	39.07	72.67.
Sandwich Is.	81.4	40.7	34.47	57.52	40.43	75.58
New Guinea	78.17	39.08	32.45	54.74	38.12	73.86
Chinese	83.23	41.64	34.80	56.82	39.25	79.30
Bush	77.28	38.64	34.42	54.57	38.5	76.46
Australia	78.82	39.41	33.7	55.89	39.11	70.42
Admirality	76.3	38.15	32.65	54.05	37.5	71.33
New Caledonia	79.22	41.11	36.32	55.2	38.41	
Negro	82.22	41.11	36.32	59.38	42.77	
Bengali	82.9	41.45	34.55	58	39.85	75.75
N.A.Indian	83.7	41.85	33.95	57.55	38.75	80.8
Burmese	85.5	42.9	35.15	58.1	39.75	80.7
Malay Peninsula	80.3	40.15	32.75	55.95	39.65	79.18
Gorilla	82.7	41.35	46.5	70.2	58	
Orang	68.5	34.25	35.76	56	43.75	
Chimpanzee	65.5	32.7	34	60	50	

Table No.1.

Now if we take another triangle say that representing the Morion skull and superimpose it on the other we shall at once see where the differences exist.

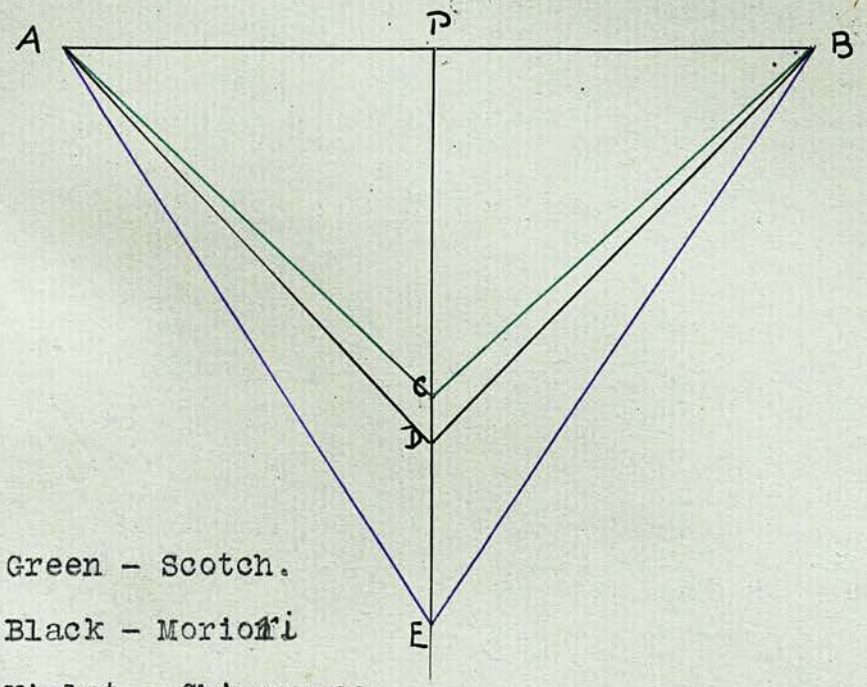


But with such a method as this it is impossible to include in one figure all the variations. To obviate this difficulty I have endeavoured to institute a means of comparison by expressing the height as a percentage of the base line, or in other words making an index expressing the proportion between the two measurements. Thus if we take 100 as the normal base line the height is expressed as a percentage of this in all cases, and if the triangles are constructed on this basis we shall have at once a graphic representation of the condition found in each and all of the groups of skulls taken: Following out such a plan the calculations were made for all the skulls in terms of a base line equaling 100 and the results are tabulated as follows :-

	Base line	½ Base line	Length of Petrous	Length of Axis of Petrous	Mid-line	Cephalic Index.
English	100	50	39.31	67.57	45.71	76.94
Scotch			38.87	68.21	46.15	78.17
Eskimo			41.45	69.28	49.33	73.15
Moriori			42.19	73.09	52.72	75.51
Maori			43.99	71.21	50.63	75
Tasmanian			41.79	71.14	49.27	72.67
Sandwich Is.			42.34	70.66	49.67	75.58
New Guinea			41.51	70.02	48.76	73.82
Chinese			41.78	68.22	47.13	79.30
Bush			44.54	70.61	49.81	76.46
Australia			42.75	70.98	49.61	70.42
Admirality			42.78	70.83	49.14	71.33
New Caledonia			42.38	69.67	48.48	70.67
Negro			44.17	72.22	52.01	73.33
Bengali			41.67	70	48.07	75.75
N.A.Indian			40.56	68.75	46.29	80.8
Burmese			40.96	67.71	46.32	80.7
Malay Penins.			40.08	68.67	49.37	79.18
Gorilla			56.22	84.62	70.31	
Orang			52.2	81.7	63.8	
Chimpanzee			51.8	91.6	76.33	

Table No.2.

It is a simple matter now to construct a figure which will include every variation found in the series, for with a base line of 100 all we require is the height of the middle line. Thus :-



Green - Scotch.
Black - Morioni
Violet - Chimpanzee.

AB = 100 = Distance between stylo mastoid foramena = base line.

PC = shortest length of middle line = 45·71 = English.

PD = longest length of middle line = 52·72 = Morion.

PE = Length of middle line in Chimpanzee.

Now if AC,CB,AD,DB be joined we get two triangles which are exactly proportional to those obtained by the actual measurements on the skull they represent. I have taken these two simply because they represent the extremes and between them lie all the others in the order given in the table. The difference between the triangles, i.e. the figure ADBC represents the

range /

range of variation which are to be found between the extremes. From this it can readily be seen that the angle formed at the apex of the triangle in the case of the Scotch skull is greater than that at the apex of the triangle in the case of the Moriori and that there is a gradual widening out in the angle as it is traced from the Moriori to the Scotch.
As regards the actual size of the angle, in the Scotch it is 96° and in the Moriori it is 90°. Further if we take the cephalic indices of the skulls as given in column IV of the table, it will be seen that it is those skulls which possess a high cephalic index which are at the top of the list with the shortest middle line and have therefore the wider angle at the apex and that those that have a low cephalic index have the longer middle line and the narrower angle at the apex. In other words the broader the skull the wider is the angle at which the petrous temporal is set to the middle line of the skull. This expresses the general rule, but the statement requires to be amplified, because although a broad skull tends to have a wider angle than a narrower one, still breadth is not the only factor to be considered in this connection. Take for example the North American Indian and the Burmese skulls. Here the skulls, judged by their Cephalic indices, are relatively broader than any other in the series, but they do not possess the greatest angle, they have a smaller angle than the English, and a practically equal one with the Scotch. So that some explanation other than mere width must

be /

be looked for. Without being able to explain the machanism of the change I think it is open to suggest that this increase in the angle is concomitant with a rise in the type of skull, and on such a supposition the condition found in the North American Indian and Burmese skulls might readily be explained. This argument also receives support in the case of the Eskimo skulls, because here although the breadth between the stylo mastoid foramina exceeds that of any other in the whole series of skulls , in addition to having a low cephalic index it also possesses a comparatively narrow angle.

To throw these points into greater contrast I have taken similar measurements of the skulls of several of the higher apes and these are appended to the other tables. They clearly tend to show that the differences seen in this region in the human skull are real differences and are the manifestations of a change that is going on in the skull base as we trace its evolution from the lower to the higher types.

Of course when I speak above of a shorter middle line in the Scotch skull than in the others, this does not necessarily imply that there is any actual shortening of that part of the cranial base under consideration, because the measurement has no actual relation to the cranial base but is determined by the inclination of the petrous bone to the middle line and it will be seen that it can quite well be modified without in itself interfering with the

actual /

actual length of the base.

One naturally asks is this change in the base measurements peculiar merely to broad skulls or is it to be found equally in narrow skulls of a high degree of development. The figures for the Burmese skulls would appear to show that it is not breadth of skull alone which determines the basal measurements, because here though we have a much broader skull than the Scotch still the figure denoting the proportion between the length and breadth of the base is greater than the Scotch and approaches that found in the lower skulls such as the Australian. To investigate what happens in a narrow skull of high mental capacity I selected six dolicocephalic Scotch skulls and measured them in every respect similar to the others. The following average figures for the six were obtained :

Cephalic Index.	Breadth at stylo mastoid foramina,
71·00.	83·3.

Length of Mid line.

45·34

Percentage proportion 45·39

From this it will be seen that these skulls although they are dolicocephalic are practically identical as regards their basal measurements when compared with the other figures for the Scotch skulls which showed an average cephalic index of 78·17. We can only conclude from this that the broadening of the base and widening of the angle at which the petrous temporal is

placed /

placed to the middle line of the skull does not depend entirely on the actual width of the skull as a whole or of the base but is a manifestation of a change in the base during the process of evolution of the skull from the lower types to the higher and is associated with the high intellectual attainment of the individual.

As to the other measurements, particularly the length of the petrous they are given along with the others in tables No. 1, page 54 . All that one can say about them is that there is a decided tendency for the skulls with a low cephalic index to have a longer petrous temporal than those having a high index, as instance, the English, Scbtch, North American Indian, Burmese as compared with the others, this is only perhaps what might be expected from what has gone before when we described the manner in which the apex in the higher skull tended to be less well defined than in the lower ones. This diminution in the length of the petrous might also be looked upon as a necessary accompaniment to the other changes which take place in the petrous because by its shortening it would tend to aid the process by which the petrous comes to lie at a greater angle to the middle line. To sum up then all these points, we find that, as the type of skull changes from the lower, as represented by the Australian and allied races, to the higher races, as represented by the Scotch and English, the base of the skull, as measured between the stylo-

mastoid /

mastoid foramina tends to increase in width, along with this there is also a change in the direction of the petrous bones each of which assumes a more transverse position, thus forming a wider angle at the middle line with its fellow on the opposite side, and also there is a tendency for the length of the petrous to become shorter ,

Another point as regards the temporal bone in the relation in the different skulls of the length of the tympanic plate or rather that part of it which lies external to the stylo-mastoid foramina and forms the floor of the external auditory meatus. As mentioned before one can see a great difference in this respect in different skulls. Perhaps the simplest way to measure this is to take the total width of the base as measured between the lower free edge of the external auditory meatus on either side and also the width between the stylo-mastoid foramina and subtract the one from the other. This gives the combined measurement of the two sides and this divided by two gives the average length of the part in question.

This was done with the following results :

	Intermeatal width.	Inter stylo mastoid width.	
Scotch	95.45 m	84.34 m	5.5 m
Bush	90.71	77.28	6.71
English	97.7	82.8	7.45
Bengali	98.6	82.9	7.85
Australian	94.44	78.82	7.86
New Guinea	95.72	78.57	8.57
Chinese	102.	83.28	9.56
Admirality Is.	95.3	76.3	9.5
Burmese	105.3	86.0	9.65
Malay Penins.	99.6	80.3	9.65
N.A.Indian	103.7	83.7	10.
Tasmanian	100.	79.3	10.35
Negro	103.22	88.22	10.5
Eskimo	109.61	87.04	11.28
New Caledonian	102.45	79.22	11.61
Moriori	107.	82.6	11.98
Sandwich Is.	106.4	81.4	12.5
Maori	113.1	82.3	15.4
Orang	77.5	68.5	14.5
Chimpanzee	106.	65.5	20.25
Gorilla	131.5	82.7	24.8

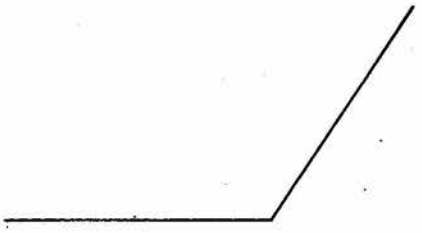
Table No.3.

From these figures we can see then that in those skulls having the greater intermeatal width the tympanic plate tends to be longer than in those skulls where the intermeatal width is less , and that it is mainly due to the decrease in the length of the tympanic part that the diminution in the intermeatal width is brought about, for coincident with the decrease in the size of the tympanic plate there is seen to be a corres-ponding decrease in the intermeatal width, a change which is not seen , at least to the same extent, in the width between the stylo-mastoid foramina . Further if we compare these figures with those at the bottom of the table for the higher apes, it will be found that here as elsewhere we get a definite indication of a gradual change as we ascend the scale. On the length of the tympanic plate depends to a great extent the depth of the external auditory meatus and as the meatus is characteristically long in the Simiidae so the comparatively greater depth of this passage in some human skulls must be associated with a lower and more primitive type of skull.

As mentioned before three bones enter into the formation of the skull base , the basi-occipital, the sphenoid and the ethmoid. This chain of bones can be divided into two parts, an anterior - horizontal part corresponding to the horizontal plate of the ethmoid and forming part of the floor of the anterior cerebral fossa, and a posterior part corresponding roughly to the slope of the basi-occipital. These two divisions

play/

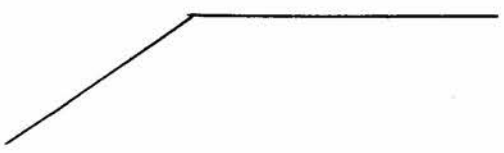
play an important part in the evolution of the human skull. In the lower animals, the dog for instance, the two lines representing these divisions form an angle which is open upward thus :



In the lowest primates the degree of flexion is not so marked

In the Simiidae the angle has become obliterated or begun to open downwards

While in man the flexion is complete, thus constituting one of the characteristics of the human skull. Along with the increased flexion however the anterior part has gradually assumed the horizontal position in the skull, so that a corresponding change has also taken place in the more centrally placed portion, thus :



The degree of flexion is measured by the spheno-

ethmoidal angle ./

angle, i.e. the angle included between the two lines drawn from the nasion and basion respectively to the prospherion. When this angle is estimated in the human skull it is found that the process of flexion has not ceased but is still going on as it is followed from the lowest form of skull up to the highest. Thus in the Australian skull the angle averages about 153 degrees while in the European it averages 138°. This being so it is natural to ask if any indication of this change can be obtained from a study of the base without having to open the skull, and is there any method of measuring the extent of the change.

Of the three points necessary for estimating this degree of flexion there are still two at our disposal - the nasion and the basion, and, while the bones of the face completely conceal the anterior or ethmoidal part of the base, there is still the basi occipital to represent the pasterior part. If therefore the angle formed by the bones of the base is wider in the Australian than in the European skull, will the change be evident from any difference in the direction of the basi-occipital as regards the other two points. It would be a comparatively simple matter to work this out provided there was any method of determining the actual length of the basi occipital, because given these three points, the nasion, the basion and the anterior extremity of the basi occipital, we have only to determine the angle formed by these lines joining these points and compare the results in various skulls. But in the great majority of skulls

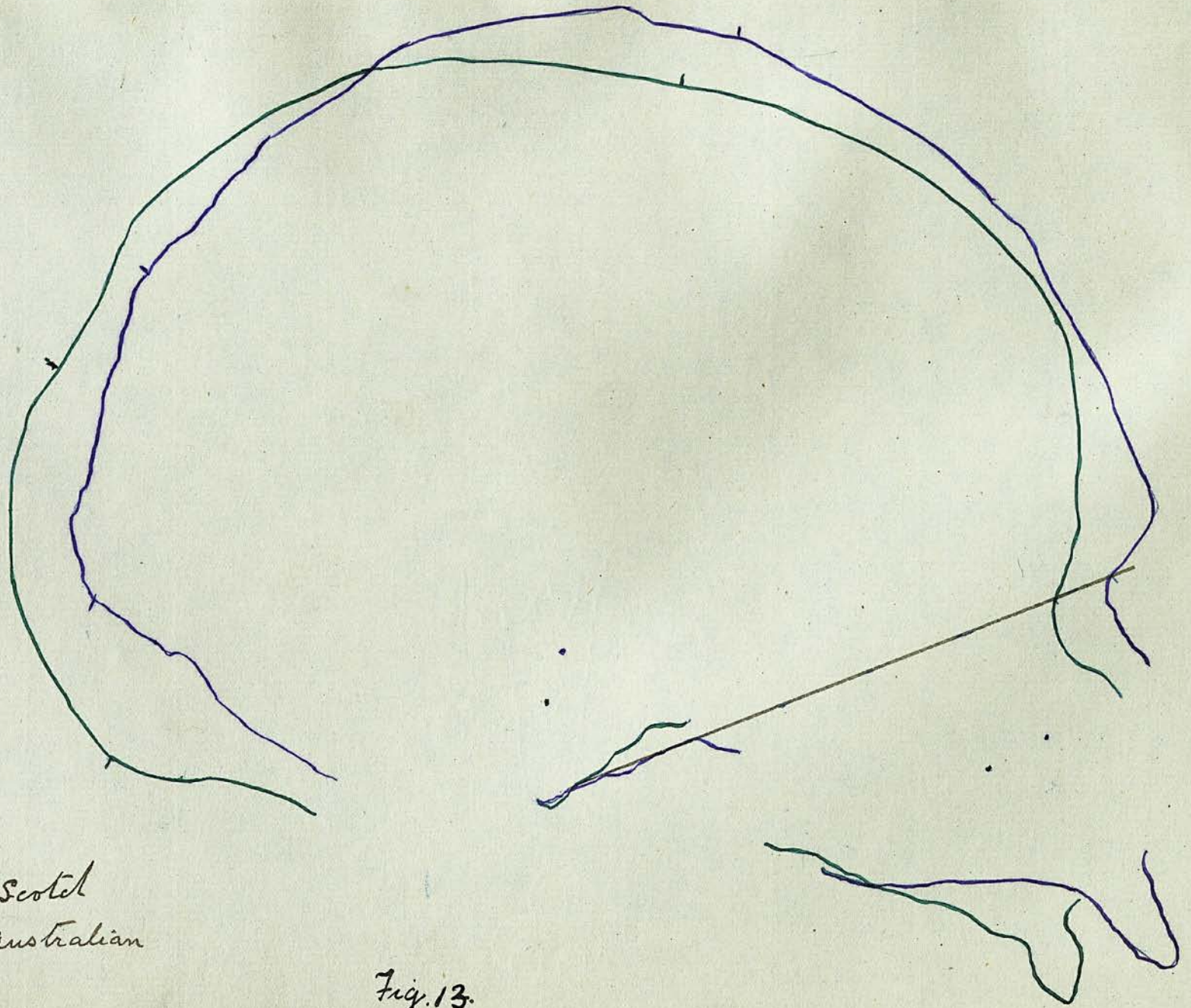
it is /

is impossible to determine with any degree of accuracy the junction between the basi-sphenoid and the basi-occipital, so that results got from following such a method would be unreliable. It resolves itself therefore into a matter of trying to estimate the actual slope at which the basi occipital is set in regard to some constant fined plane, and comparing the results got for the different lots of skulls. If two skulls are taken, one a low grade Australian and the other a high grade European, and their base compared in connection with the points referred to above, well marked differences are evident between them : In the Australian the basi occipital seems much flatter and to rise with much less of a slope than in the other. But is this apparent or real ? For it must be remembered that other factors come in here which may have a great influence on one's judgment in the matter; and particularly in this case in regard to the presence or absence of any degree of prognathism; because with a marked degree of prognathism, such as is found in the Australian skull the angle formed by the basi occipital and the pterygoid plates and the vomer is much more open than it is in the Scotch with its orthognathic character. The recess in the Australian skull is wide and open while in the Scotch it is comparatively narrow so that the distance separating the lower border of the basi-occipital from the posterior nasal spine is very much more in the Australian than in the Scotch. This in itself would tend to produce the impression that both factors in the pro-

duction of the /

the angle were set at a much acute angle in the Scotch than in the Australian. Obviously then both of these factors must be analysed in order to find out whether this difference is apparent or real. I have tried to arrive at a definite conclusion by adopting the following method : the skull was placed in Wetzel's craniophor and orientated in such a way that a sagittal tracing was taken of the skull by means of the perigraph. If the basi-nasal line be taken as the fixed line and the basion be taken as the most fixed point in that line then we are able to superimpose the tracings got from the two skulls as under.

[Fig. 12 page 69



Green. – Scotch
Violet – Australian

Fig. 13.

The tracings speak for themselves and they show in a marked degree the difference in the relative obliquity of the basi occipital relative because it is taken in regard to the basi nasal line. But it is to be remembered that the difference in position as thus shown may not really lie with the basi occipital at all, but may depend entirely on the downward (interior) of the nasion due to flexion taking place of the anterior part on the posterior, the posterior part remaining stationary, most probably both factors come into force in the matter, at any rate such methods as this show us that a change has taken place, though it may not tell us anything as regards the manner in which it has been brought about. ?

Again it must not be thought that all the Australian skulls present such a small degree of obliquity of the basi occipital as the one shewn in the figure, many of them show curves which closely approximate and often equal the higher types, and the same is true in the reverse manner of the Scotch. Bearing such points in mind however, some such methods as that described should enable us to arrive at some idea of the conditions which exist in the various skulls in this respect. Tracings similar to the above were obtained of all the skulls and the basi nasal line drawn in, the distance was then measured on all the tracings from the basi nasal line to the point on the tracing which represented the highest point of the basi occipital, i.e. the point farthest away from the

basi-nasal /

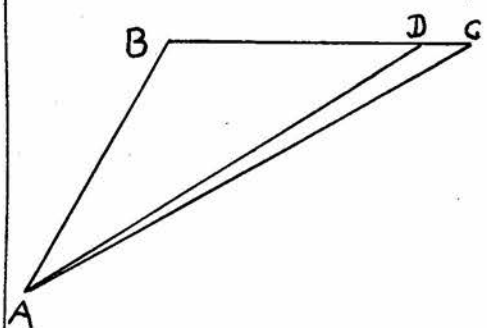
nasal line. This was done by dropping a perpendicular to the basi nasal line from that point and measuring the length of the perpendicular.

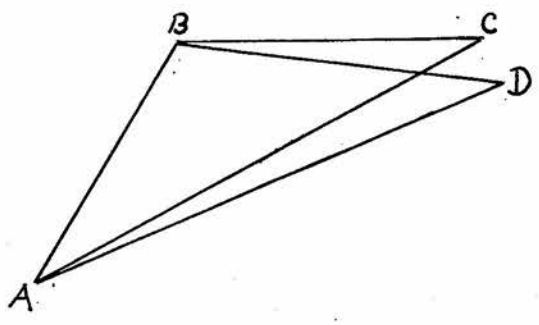
The following results were obtained :

Eskimo,	·15 m.
Chatham Is.	·75
Sandwich Is.	1·7
Maori,	2·37
New Caledonia,	2·5
Admiralty Is.	2·5
Tasmanian,	2·6
Australian,	2·7
Negro,	2·8
Chinese,	2·8
Malay Penins.	3
North Am. Indian,	3
English,	3·2
Bengali,	3·6
Burmese,	3·8
Scotch,	4·57
Bush,	5·7
Gorilla,	24·25
Orang,	16
Chimpanzee,	14·5

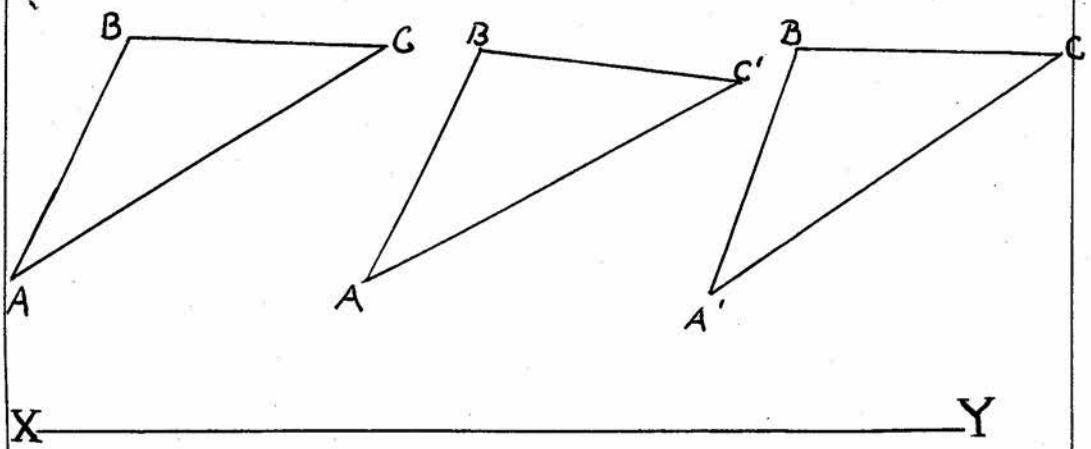
Table No.4.

From this table it will be seen that there is a slight variation in the angle at which the basi-occipital is set in respect of the basi-nasal line, and also, that although in individual skulls we may get the basi-occipital occasionally falling below the basi nasal line, yet on averaging all the measurements there is no group of skulls in which it falls below it. In the higher apes however this is the normal condition the inclination ranging from 14·5 m. to 24·25 m. on the other side of the basi nasal line. In the human skull the slope ranges from ·15 m. in the Eskimo to 5·7 m. in the Bush skull. This means that in the Eskimo the slope of the basi occipital departs at its highest point for a distance of .15 m. from the basi nasal line, and in the other the slope is increased to 5·7 m., while in the remaining skulls the basi occipital is set at intermediate position between the extremes. These figures taken by themselves, however, tell us nothing about the actual relationship of the two component parts of the base and the part they play in bringing the change about, because if we represent the base by the following figure, where AB represents the posterior division and BC the anterior and AC the basi nasal line.





We can easily see that such a condition as is represented by the lowest figures in the foregoing table could be brought about in several ways, for instance, if BC be shortened to BD and AD joined the triangle ABD would represent the condition found in the earlier part of the series, also if AB were shortened similar results would be obtained. Again if BC be bent to BD the triangle ABC now represents the first series, and ABD the later series, and if AB be bent on BC the same results accrue. In the first two instances angle ABC (the spheno-ethmoidal angle) remains the same, but in the second two the angle ABC has decreased. We know that this is what actually takes place when we pass from the higher to the lower skulls, so that we can conclude that this increased slope of the basi-occipital in respect of the basi nasal line is the result of the increased flexion taking place between the two divisions of the base. I do not see how we can go beyond this, all investigations as to whether this change in the base is brought about by the independent action of either of the component parts of the base or whether they both take part in it seems to be futile on account of the insufficiency of the data to go upon. Take the figure ABC as representing the condition found in the Australian skull, AB representing the posterior part of the base, BC the anterior, and AC the basi nasal line. ABC = the spheno-ethmoidal angle and XY the horizontal.



Now if we assume that in the evolution of the skull flexion has taken place by BC being bent on AB, we get the figure ABC'. But if it is assumed that the flexion took place by AB being bent on BC we get a figure A'BC the flexion being such that the basi-nasal line remains equal. Now the two figures A'BC and ABC' are identical the only difference between them being in their relationship to the horizontal. From this we see that if we had any means of accurately getting at the relation of the skull to the horizontal and how it varies in different groups, it would then be a simple matter to determine the part played by each factor in the production of the change. We have got no such method and consequently must be content to leave the question undecided.

Coming now to the length of the basi-nasal line, if there is this flexion going on in the spheno-ethmoidal angle one should naturally expect to find a corresponding diminution in the length of the distance from the nasion to the basion; that is, provided the length of the two portions of the base remain the same. The actual measurements are given on page 75 .

	Nasion basion m	Greatest length. m	proportion m
Bush	92.II	I73.55.	53.07.
Admirality Is.	96.	I79.3.	53.87.
Chinese	95.38.	I73.84.	54.86.
English	97.4.	I84.8	52.7
Scotch	97.55	I84.	52.7
Bengali	97.9	I76.5	55.46
New Caledonian	99.	I85.09	53.43
New Guinea	99.	I74.37	56.77
Malay Peninsu.	99.	I74.4	56.76
N American In.	99.7	I75.3	56.8
Australian	I00.I2	I8I.86	55.05
Burmese	I00.4	I74,I	57.66
Tasmanian	I0I.	I82.8	55.2
Sandwich Is.	I0I.8	I82.45	55.79
Maori	I04,25	I85.	56.35
Negro	I04.I	I84.77	56.34
Eskimo	I04.23	I84.	56.64
Morori	I04.6	I86.53	56.I7

Table No 5

Greatest breadth m	proportion	Cephalic index.
I32.7I	69.4	76.46
I27.9	75.05	7I.33
I40.7	68.I3	80.53
I42.2	68.45	76.94
I43.85	67.8I	78.I7
I33.7	73.22	75.76
I30.8I	75.68	70.67
I28.8I	76.86	73.86
I28.I	7I.69	79.I8
I4I.6	74.09	80.I8
I28.08	78.I7	70.42
I40.5	7I.45	80.7
I32.85	76.02	72.67
I37.9	73.82	75.58
I38.75	75.I3	75.
I35.5	76.82	73.33
I34.6	77.43	73.I5
I40.86	74.30	75.0I

Taking the figures generally it is seen that the shortest nasion-basion length goes with the shortest total length of the skull and similarly the greatest nasion-basion length goes with the greatest length of skull, and, with the exception of the English, Scotch and Burmese, the same ratio is fairly well maintained throughout the series.

In the Scotch and English we have a comparatively short nasion-basion length while the total length remains high and in the Burmese the opposite holds good; the basi-nasal length is high while the total length is low. It is obvious then that to gain an accurate idea of the relative length of the measurement we must express it as a percentage, taking 100 as the constant total length; the result is seen in the 3rd. column of the table. From this it is seen that were the length of the skull taken as 100, the length of the basi nasal line would vary between 52·7 and 57·66. The English and Scotch skulls show the smallest proportion and it gradually increases in the various races till it reaches its maximum in the Burmese. This then would appear to show that the proportion between the two measurements, i.e. the basi nasal and the total length becomes less as the higher type of skull is reached. Of course a statement merely of the varying proportions between these two measurements gives us no information as to which of these measurements the change is due, because a change in either may produce similar results. Thus take the Australian skull, the greatest length is 181· and the

nasion /

nasion basion length is 100·12. the percentage being 55·05. If the total length be increased to 186 then the percentage becomes 53·7 , and if the basi nasal line be diminuted to 97·19 the same percentage is obtained. A study of the actual figures would serve to show however that the principal change has taken place in the basi-nasal line. In the majority of cases the differences between the total length is much less than the differences between the basi-nasal lengths. In the English, Scotch, Tasmanian, Sandwich Is.,Maori, Negro, Eskimo and Moriori skulls the difference between the lengths of the skull does not exceed two millimetres yet the lengths of the basi nasal line have a range of differences of 7 millimetres. Certainly with the exception of the Bush skulls and the Chinese the basi nasal lines in the English and Scotch are the shortest of any others in the whole series, while their total lengths are greater than the great majority of the others, being only exceeded by three.

The statement made above that the proportion between these two measurements becomes less as the higher type is approached would seem to be negatived by the condition found in the Burmese skulls. Here with a cephalic index of 80, the percentage proportion between the total and the basi nasal length is 57, higher than that in any other. This is readily explained by the fact that a cephalic index of 80 does not necessarily imply a very high type of skull, that in fact such a skull may quite well represent a skull

with /

with a much lower mental capacity than one whose cephalic index is considerably lower. The Burmese skull depends for its Brachycephalic character mainly on the reduction in total length due to the peculiar flattening of the posterior part of the skull, and while we may regard brachycephalism and mesaticephalism as more characteristic of a high mental attainment than dolichocephaly we may look upon the Burmese skull as an imperfect and rude example of the type it represents; this is also borne out, as shall be seen afterwards, from a consideration of the basal measurements; these do not bear the same proportion to each other as would be expected from the high cephalic index; so that we might look upon the Burmese skull as really possessing two characters - a high type as indicated by the cephalic index and determined by the principal dimension of the cranial cavity, and a low type in regard to the basal measurements; hence the long basi nasal line and the high percentage proportion between it and the greatest length.

Perhaps this might be better seen were this line correlated with the greatest width of the skull. I have added figures indicating this in column VI of the tables on page 75 .

Here also we can see that as a rule in the broader skulls the proportion between the basi nasal line and the greatest breadth is smaller than in the narrower skulls and if the cephalic index be taken as a guide and the skulls arranged in accordance with this, this association is very clear.

	Cephalic Index.	percentage proportion Nasion basion x 100 / Greatest breadth
Burmese	80.7	71.45
N American Indi.	80.18	74.09
Chinese	80.50	68.13
Malay Peninsular	79.18	71.69
Scotch	78.7	67.81
English	76.94	68.49
Bush	76.46	69.4
Moriori	75.51	74.3
Sandwich Is.	75.58	73.82
Bengali	75.76	73.22
Maori	75.	75.13
Eskimo	73.15	77.43
Negro	73.33	76.82
New Guinea	73.86	76.86
Tasmanian	72.67	76.02
Admirality	71.33	75.05
Australian	70.42	78.17
New Caledonian	70.67	75.67

Table No.6.

Here it is seen that, with two exceptions, i.e. the Burmese and North American Indian, in those skulls having a high cephalic index the percentage proportion of the basi-nasal line to the greatest breadth is smaller than in those with a lower cephalic index, showing that in skulls with a low index the basi nasal line is not only absolutely but also relatively longer than in those with a high index. Of course some of the skulls show this contrast more so than others, take the Australian and the Scotch and contrast them in this respect.

	Greatest length.	Nasion basion.	Greatest breadth.	C.I.	Percentage prop. between nasion basion & greatest breadth.
	m	m	m		
Scotch,	184	97	143	78·72	67·81.
Australian,	182	100·12	128	70·42	78·17.
Maori,	185	104	138·75	75	75·13.

Here although the Australian has a shorter total length the basi nasal line is longer, it is much narrower and shews a cephalic index of 70·42 and the proportion between the basi nasal line and the greatest breadth is much lower, similarly if the Maori skull is taken, where the total length is longer than in the Scotch we get very much the same conditions holding. From this it is apparent that there must be a gradual shortening of the basi-nasal line as we trace it from the lower to the higher types.

I investigated the distance of the posterior point of the vomer from the nasion and basion respectively thinking to find some indication here also of the

degree /

degree of flexion of the base. The figures however as will be seen from table No. page do not indicate anything definite in this connection because in practically every case when the various distances from the skulls in each series were averaged up the sum of the two lengths almost exactly equalled the whole length from nasion to basion showing that the basi-nasal line passes through the posterior point of the vomer. But there are other points of interest which can be made out in this connection. On looking at the figures in table No. 7, on page 82 it will be seen that the distance from the vomer to the basion varies apparently almost directly with the nasion basion length; so that with a long basi nasal line the distance from the vomer to the basion is longer than with a shorter basi-nasal line; but if the two be expressed as a percentage it will be seen that the variation is not exactly proportional, this is shewn in column III. Here the percentage varies between 28 & 30, the Scotch and English possessing the smaller figure; it would seem therefore that in the Scotch and English Skulls the vomer has come to take up a position further back on the base than in the others. This might quite well be explained by the increased flexion in the basal elements of the skull as noted above, but much more probably it is due to the reduction in the amount of prognathism of the facial bones in the respective skulls by which the vomer not only, along with the other bones of the face is set at a much straighter angle to the basis cranii

but /

	1 Vomer basion	2 Nasion basion	3 %proportion
Chinese	28.6I m	95.38 m	29.99 m
Bush	28.	92.II	30.39
English	28.2	97.4	28.95
Scotch	28.	97.05	28.83
Admirality Is.	28.	96.	29.47
New Guinea	25.5	99.	29.79
Burmese	30.	I00.4	29.88
N.Ameri.Indian	30.I	99.7	30.I9
Bengali	30.4	97.9	3I.05
Malay Peninsu.	30.5	99.	20.8
Australian	30.24	I00.I2	30.02
New Caledonian	30.36	99.	30.66
Tasmanian	30.85	I0I.	30.54
Maori	3I.I	I04,25	29.83
Sandwich Is.	3I.4	I0I.8	30.84
Moriori	3I.8	I04.66	30.38
Negro	32.32	I04.I	3I.04
Eskimo	33.07	I04.23	3I.72
Gorilla	48.5	I36.25	35.6
Orang	34.5	87.25	39.54
Chimpanzee	42.	I06.5	39.43

Table No.7.

but also has been bodily carried backwards nearer the basion.

Coming now to measurements that have to do with the width of the base, in dealing with these several well marked symmetrical points on either side were selected and the distances between them taken. In this way were measured,

(1) The greatest width.
(2) The width at the posterior root of the zygoma.
(3) The width at the stylo mastoid foramina.
(4) The width at the lower edge of the meatus.
(5) The width between the sphenoidal spines.
(6) The width at the narrowest part of the infra-temporal ridge.

The actual figures obtained for these measurements are given in table No. 8, page 84 . As to the first column - the greatest breadth - this is lowest in the Admirality Islands group with 127·9 m. and highest in the English and Scotch with 142 m. and 143·85 respectively. The percentage proportion between this and the greatest length is of course the cephalic Index.

As regards the breadth at the posterior root of the zygoma this must be looked upon as a measure of the total width of the base just as the nasion-basion line is the measure of the length of the base. It will be seen from a glance at the figures that this measurement and the greatest width do not bear a constant ratio to each other. In some skulls we are

able /

	Greatest breadth of Skull.	Breadth at posterior root of Zygoma.	Intermeatal Width.	Interspinous width.	Width at infratemporal ridge.
Sandwich Is.	137.9m.	121.9m.	106.4m .	71.2m.	65.35m.
Australian	128.08	114.64	94.44	68.63	67.76
Maori	138.75	124.9	113.1	73.9	68.3
Negro	135.5	118.11	103.22	71.55	71.55
Chinese	140	124.23	102	73.3	70.61
New Guinea	128.81	116.25	95.72	68.06	64.75
Admirality Is.	127.9	115.8	95.3	68.1	63.8
Tasmania	132.85	118.5	100	70.55	67.85
Bush	132.71	112.85	90.71	67.28	66.85
English	142.2	121	97.7	70.6	70.3
New Caledonian	130.81	117.45	102.45	71.9	65.25
Scotch	143.85	124.75	95.45	72.25	70.55
Moriori	140.86	128.2	107	72.43	68.53
Bengali	133.7	115.8	98	70.5	68.7
N.A.Indian	141.6	128.2	103.7	73.0	72.8
Burmese	140.5	125.5	105.3	74.9	72.1
Malay	138.1	121.3	99.6	72.4	71.2

Table No.8.

able to see some general proportion between them but in others this relationship is quite upset. For instance in the Scotch, Admiralty, Bengali, New Guinea and Malay skulls we see a general indication present that the wider cranial measurement carries with it a corresponding wider base measurement. While in the North American Indian, Moriori and Eskimo skulls the opposite condition holds, where although more of them possess such a wide cranial measurement as the Scotch, yet all possess a wider base measurement. From this we are hardly able to draw any definate conclusion as to the relationship these two measurements . If however they are put in the form of a percentage, as is done on page 86 one thing becomes clear; and that is that the percentage proportion between these two measure--ments is greatest in those skulls possessing the widest bases and lowest in the English and Scotch. Again if the Scotch and Admiralty Islands skulls be taken as examples, merely because they show the extremes in cranial width, it will be seen that the proportion between the two measurements is 86·72 in the former and 90·54 in the latter, the Scotch having, however, a base width of 124·75, and the Admirality of 115.8 m; this shows that, taking the Admirality skull as the more primitive type, although the base of the Scotch skull has increased in width along with the increase in the cranial width still it has not grown directly in the same proportion. It would have required a base breadth of 129.8 m. in the Scotch to make the increase proportional: and if this be taken as the state of

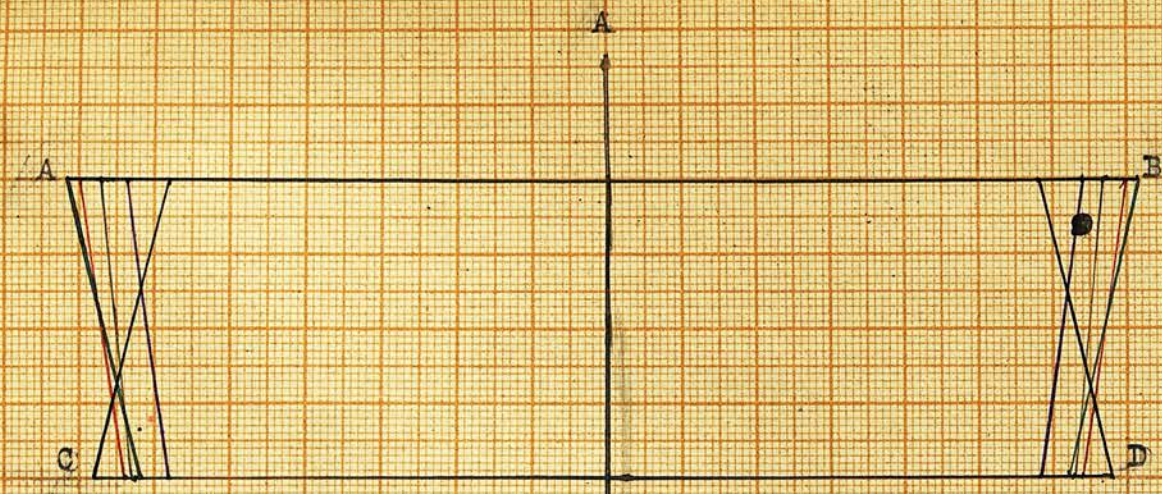
affairs /

Percentage age proportion between width at post.root of zygoma & greatest breadth.

Bush	85.03
English	85.07
Scotch	86.72
Bengali	86.61
Negro	87.15
Malay Peninsular	87.83
Sandwich Is.	89.
Tasmanian	89.19
Burmese	89.32
Chinese	89.73
New Caledonian	89.78
Maori	90.
New Guinea	90.24
N.American Indian	90.53
Admirality	90.54
Moriori	91.08
Eskimo	93.48

Table No.9.

affairs, then the figures obtained in the Eskimo and Moriori might quite well be looked upon as extreme examples of the same thing, the condition found in these approaching that in the higher apes where the width of the base exceeds the total cranial width. Perhaps a reference to the figure on page will make the relation of these measurements clearer. The upper line represents the greatest width of the skull and the lower one the width of the base at the posterior root of the zygoma. On both are marked off the measurements of the various skulls at these parts, the extremities being joined by a straight line. Figure 1 gives the actual figures; fig.2 the percentage proportion between the two measurements. From this it will be seen that if the Scotch and Anthropoid Apes are regarded as extremes the whole change from one to the other can be brought about by a progressive change in the direction of the side lines due to an increase in the greatest width and a decrease in the basal width. From it also is seen how the Moriori and Eskimo skulls and indeed the Australian and New Guinea skulls partake of the character of the Anthropoid skull in this respect. The diagram does not pretend to fully explain what the relation between the two measurements really is, but it serves to show in a general way what takes place. The question of the relation of cranial width to mental capacity is necessarily broached here but it will be dealth with further on. It will be sufficient here to refer to a few points that strike one in passing; that breadth of base and breadth of cranial cavity are evidently



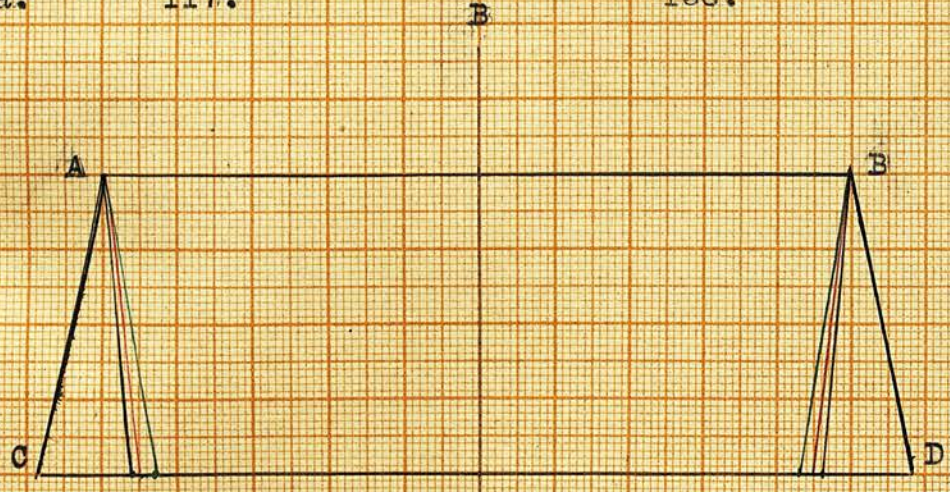
Actual measurements.

Indian black = Gorilla.
Black = Eskimo.
Red = Moriori.
Green = Scotch.
Violet = Australian & New Guinea.

A.B.= Greateat width of Skull.

C.D.= Width at posterior root of zygoma.

	Greatest width.	Width at post root of zygoma.
Scotch	I43.	I24.
Moriori	I40.	I28.
Eskimo	I34.	I25.
Australian	I28.	II6.
Gorilla.	II7.	I36.



Relative proportion taken the greatest width as I00.

The Moriori, New Guinea & Australian skulls shew almost the same percentage proportion: and are represented in red.

	Greatest width.	Width at post root of zygoma.
Scotch	I00.	86.72
Moriori	I00.	91.08
Eskimo	I00.	93.48
New Guinea Australian	I00.	90.24
Gorilla	I00.	II6.

Fig. 14.

two independent things and that while a narrow base generally denotes a low type of skull e.g. that of the Admirality Islander , a broad base is not necessarily a guarantee of intellectual superiority e.g. Eskimo and Moriori skulls. The proportion between the two however would seem to afford more reliable information as regards mental capacity, because although the actual measurements vary on either side of the figures for the Scotch and English, yet in almost every case the prcportion is represented by a higher figure than for them. It may be better perhaps if this meaurement were to be compared with the length of the base and an idea is thus got of the relative proportion of the length and breadth of the skull base in different skulls. For this purpose the basi-nasal length was taken as denoting the length of the base and with these two measurements an index was worked out the length being given as a percentage of the breadth.

The results are seen in table No. 10, page 90 here the indications are clearer for if we co-relate the figures thus obtained with the cephalic index it is found that the smaller proportion as a rule goes with the higher cephalic index and vice versa. Thus in the Scotch with a cephalic index of 78.7 the proportion is 78.19 while in the New Caledonian with a cephalic index of 70.67 the proportion is 84.28.

From this then it would appear that the characters which are seen in the cranial measurements are reflected to a greater or lesser extent in the base; the skull possessing a comparatively broad cranial diameter also

possessing/

	Breadth of base at posterior root of Zygoma.	Basi-nasal line.	Percentage proportion.	Cephalic Index.
Chinese,	124.23 m.	95.38	76.77	80.53.
North Am.Indian,	128.2	99.7	77.76	80.18.
Scotch,	124.75	97.55	78.19	78.7
Burmese,	125.5	100.4	80	80.1.
English,	121	97.4	80.49	76.94.
Bush,	112.83	92	81.52	76.46.
Moriori,	128.2	104.6	81.59	75.51.
Malay Penins.	121.3	99	81.61	79.18.
Eskimo,	125.84	104.23	82.82	73.15.
Admirality,	115.8	96	82.90	71.33.
Maori,	124.9	104.25	83.46	75
Sandwich Is.	121.9	101.8	83.51	75.58.
New Caledonia,	117.45	99	84.28	70.67.
Bengali,	115.8	97.9	84.53	75.76.
New Guinea,	116.25	99	85.16	73.86.
Tasmania,	118.5	101	85.23	72.67.
Negro,	118.11	104.1	88.13	73.33.
Australian,	114.64	100.12	87.33	70.42.
Gorilla,	136.25	136.25	100	
Orang,	109.75	87.25	79.5	
Chimpanzee,	115.5	106.5	92.2	

Table No.10.

possessing a broad base and vice versa. It is also seen how the Burmese, Moriori and Eskimo skulls, although possessing a greater basal width than the Scotch and English skulls, yet in virtue of their proportionally long basi-nasal line are to be associated with the lower and more primitive type of skull. Of course an objection that may be lodged against the use of this measurement i.e. the width at the posterior root of the zygoma , is that it is unreliable, being subject to variation due to the presence or absence of boney development at this point; and as skulls vary in this direction immensely, both inter and intra racially, comparisons instituted between skulls by means of this meaurement are apt to be fallacious. But looking at it either way, I think that at any rate for our purpose the measurement is worthy of consideration; for if this variation were a general thing among all classes of skulls without reference to any particular race or races, its influence on the measurement, provided a sufficient number of skulls be taken in each class, would be the same throughout the whole series of skulls and therefore the figures for this particular measurement would remain valid; but if the development of well-formed and distinct boney prominences and ridges be regarded as a characteristic of certain races, and we are accustomed to look to the lower types of skulls such as the Australian as being associated with this characteristic in a greater degree than the higher skulls, the figures still remain good, because the

influence/

influence of the inbreased boney projection is all in the direction of increasing the width at this particular point and it will be readily seen that if any reduction were to be made in the figures representing this measurement in table No.10, page 90 the contrast in the percentage proportion between these skulls and the higher ones would be rendered even greater than it is.

Passing to the width between the stylo mastoid foramina - this measurement perhaps more than any other gives the most reliable information as to the width of the base, it is not open to objection on the same score as the previous one. First as regards the actual measurement in each group of skulls this is given on page 43 . It will be seen that this varies from 76 m. in the Admirality Islands group to 87 m. in the Eskimo. If these figures are compared with the cephalic index for the skulls a fairly definite ratio is seen to exist between the two the narrower width going with the lower cephalic index, and the higher index having the wider breadth. This is fairly constant for all with the exception of the Eskimo in which with a low cephalic index there is still the maximum breadth.

It is interesting to compare this measurement with the greatest breadth of the skull and to see whether the conditions which were found in the measurements at the posterior root of the zygoma still obtain here. The figures are given in col. IV page 93 . Here we see that just as before the figures for the Eskimo

skulls /

	Breadth at Stylo-mastoid Foramina.	Cephalic Index.	Greatest Breadth.	Age proportion between Stylo-mastoid breadth & greatest breadth.
Admirality	76. m.	71.33m.	127.9 m.	59.42m.
Bush	77.28	76.46	132.74	58.21
New Guinea	78.5	73.86	128.82	60.93
Australian	78.82	70.42	128.08	61.54
New Caledonia	79.22	70.69	130.81	60.56
Tasmania	79.3	72.67	132.85	59.67
Malay Penins.	80.3	79.18	138.1	58.14
Sandwich Is.	81.4	75.58	137.9	59.02
Negro	82.22	73.33	135.5	60.67
Maori	82.3	75	138.87	59.26
Moriori	82.6	75.51	140.86	58.63
Bengali	82.9	75.75	133.7	62.0
Chinese	83.23	80.53	140.	59.45
English	83.3	76.94	142.2	58.57
N.A.Indian	83.7	80.8	141.6	59.11
Scotch	84.34	78.19	143.85	58.63
Burmese	86.	80.7	140.5	61.21
Eskimo	87.	73.15	134.61	64.63
Gorilla	82.7		117.5	70.38
Orang	68.5		98	70
Chimpanzee	65.5		105	61.9

Table No.11.

skulls are still the greatest but in the Moriori the distance has become reduced to below that for several of the others, thus bringing it more into line; the percentage proportion between them is given in Column IV. It will be seen that the variation is very slight but that the English and Scotch tend to have the smallest figure; in this respect it harmonises with the result obtained with the previous measurement ; and if a figure be constructed similar to that on page the same general relationship will be found to exist in the various skulls as regards this measurement and the greatest width as are indicated there for the breadth at the posterior root of the zygoma. What has been said therefore in connection with the previous measurement equally applies to this : so that from a consideration of these two measurements we would seem to be justified in drawing the conclusion that the change from the condition found in the anthropoid apes and omit in the lower types of the human skull to that found in the highest human type has been brought about chiefly by an expansion of the cranial width, and that along with this there has been a widening of the cranial base - this widening however being relative and not absolute, nor in every case proportional to the increase in the cranial measurement, since some skulls possessing a narrower cranial width than others may show a wider base e.g. the Eskimo; when this is the case it would seem to indicate either a return to a more primitive condition or to a development along different lines.

Lastly/

Lastly as regards its relation to the nasion basion line , the two measurements and the proportion between them are given on page 96 . From this table it will be seen that the proportion gradually increases from the lower to the higher skulls. This naturally could be brought about by either the breadth measurement becoming greater or the nasion basion length becoming shorter or by an association of these two : that the last method is the more probable is seen from the actual figures in the table and also from what we have already said in relation to the breadth. It is well illustrated by taking the two extreme types in the series i.e. the Australian and the Scotch

	Basi nasal line.	Breadth at stylo mastoid foram.	% age proportion.
Australian,	100.12m.	78.82m.	78.51.
Scotch,	97.05m.	84.34m.	86.96.

As regards the intermeatal width this has been referred to before in connection with the tympanic plate and from what has been said then it will be seen that the measurement as distinct from the one just considered depends entirely on the length of the tympanic part of the bone: so that any further discussion of it is unnecessary.

As to the intraspinous width, the figures for it are given on page 99 . As they stand there does not seem to be much variation present in the measurements throughout the various skulls. One or two points can be made out however: the long narrow skulls, such as those from Admirality Islands, the Australian and New

Caledonian /

	Basi-nasal line.	Breadth at Stylo-mastoid foramin	Index
Tasmania	101 m	79.3 m	78.51 m
Australian	100.12	78.82	78.72
Maori	104.25	82.3	78.94
Negro	104.1	82.22	78.98
Sandwich	101.8	81.4	79.96
New Guinea	99.	78.5	79.36
Moriori	104.66	82.6	78.92
New Caledonia	99	79.22	80.02
Admirality Is.	96	76.3	79.47
Malay Penins.	99	80.3	81.11
Eskimo	104.23	87.04	83.5
Bush	92.11	77.28	83.9
N.A. Indian	99.7	83.7	83.95
English	97.4	83.3	86.03
Burmese	100.4	86	85.65
Chinese	95.38	83.23	87.26
Scotch	97.05	84.34	86.96
Bengali	97.9	82.9	84.63
Gorilla	136.25	82.7	60.69
Orang	87.25	68.5	78.5
Chimpanzee	106.5	65.5	61.5

Table No.12.

	Interspinous width.	Nasion basion.	Index.	Cephalic Index.
New Caledonian	67.37 m.	99 m.	68.05 m.	70.63 m.
Australian	68	101.2	68.54	70.42
Negro	71.55	104.1	68.73	73.33
New Guinea	68.06	99	68.74	73.86
Moriori	72.4	104.66	69.17	75.51
Tasmanian	70.55	101	69.85	72.67
Sandwich Is.	71.2	101.8	69.94	75.58
Maori	73.9	104.25	70.88	75
Admirality Is.	68.1	96	70.93	71.33
Bengali	70.5	97.9	72.01	75.76
English	70.6	97.4	72.48	76.94
Bush	67.28	92.11	73.04	76.46
Malay Penins.	72.4	99	73.13	79.18
N.A. Indian	73	99.7	73.21	80.18
Eskimo	76.92	104.23	73.79	73.15
Scotch	72.25	97.05	74.44	78.7
Burmese	74.9	100.4	74.13	80.7
Chinese	73.3	95.38	76.85	80.53

Table No.13.

Caledonian possess the smallest figures, while the higher figures are held by the broader skulls. The great exception to this rule is the Eskimo. Here we have a typical dolichocephalic skull with a breadth in excess of the most brachycephalic skulls in the series, but this is characteristic of the skull in all its basal measurements of width and has been spoken of before. Neglecting the Eskimo skull then, we find the smallest measurements in the most dolichocephalic skull and the highest measurement in the most brachycephalic, while between them are grouped the other skulls preserving as a rule the relation mentioned above.

So that from a study of the figures alone we see that there has been a slight increase in the width of the base here, co-incident with the rise in the cephalic index and that the increase is much on the same lines as has been found in the other basal width measurements. Further if a comparison be made between this width and the nasion basion line it will be seen that the relation between them varies almost directly with the cephalic index, showing again that the characters of the skull as denoted by the measurements of the greatest length and breadth of the cranial cavity are reflected more or less closely in the measurements of the base. The same remarks apply to the measurements taken at the infra-temporal crest, only in a lesser degree; for here the variation is much less marked than in the other: all that can be said indeed is that the tendency is for the lower skulls to have a

smaller /

	Breadth at Infra temp crest	Nasion basion	Index
Sandwich Is	65.35 m	101.8 m	64.09
Austalia	67.76	100.2	67.6
Maori	68.3	104.25	65.51
Negro	71.55	104.1	68.73
Chinese	71.13	96.4	73.7
New Cuinea	64.75	99.	65.4
Admirality	63.8	96.	66.45
Tasmania	67.85	101.	67.17
Bush	66.85	92.11	72.57
English	70.3	97.4	72.17
Eskimo	72.15	104.23	69.23
New Caledonia	65.25	99.	65.9
Scotch	70.55	97.05	72.69
Moriori	68.53	104.66	65.47
Bengali	68.7	97.9	70.17
N.A.Indian	72.8	99.7	73.00
Burmese	72.1	100.4	71.81
Malay	71.2	99.	71.92
Gorilla	66.25	136.25	55.9
Orang	55.25	87.25	63.32
Chimpanzee	58.	106.5	54.46

Table No.14.

smaller figure than the higher ones. The percentage proportion between it and the basi nasal line varies practically in the same way as the previous measurement.

It would seem then from a consideration of the various measurements, that, as regards width the base is just as subject to variations as is any other part of the skull; and that, as a general rule, this variation is directly related to changes in the measurement of the greatest length and breadth of the skull. In general, an increase in the basal width goes along with a increase in the total width, and vice versa; and further, that the base as a whole does not take part equally in all regions in this increase. It is in the more centrally situated parts of the base, i.e. in the plane of the stylo mastoid foramina, that the increase is most apparent, while it is not so marked at the region of the spina angularis or the infra-temporal ridge. This is illustrated by the following figures which are the average tracings for the Scotch and Australian skulls.

Breadth at stylo mastoid foramina.

Scotch, 84.34m.

Australian, 78.82m.

Breadth at posterior root of zygoma.

Scotch, 124.75m.

Australian, 114.64m.

Breadth at Spina angularis,

Scotch, 72.25.

Australian, 68.25.

Breadth at infra temporal crest,

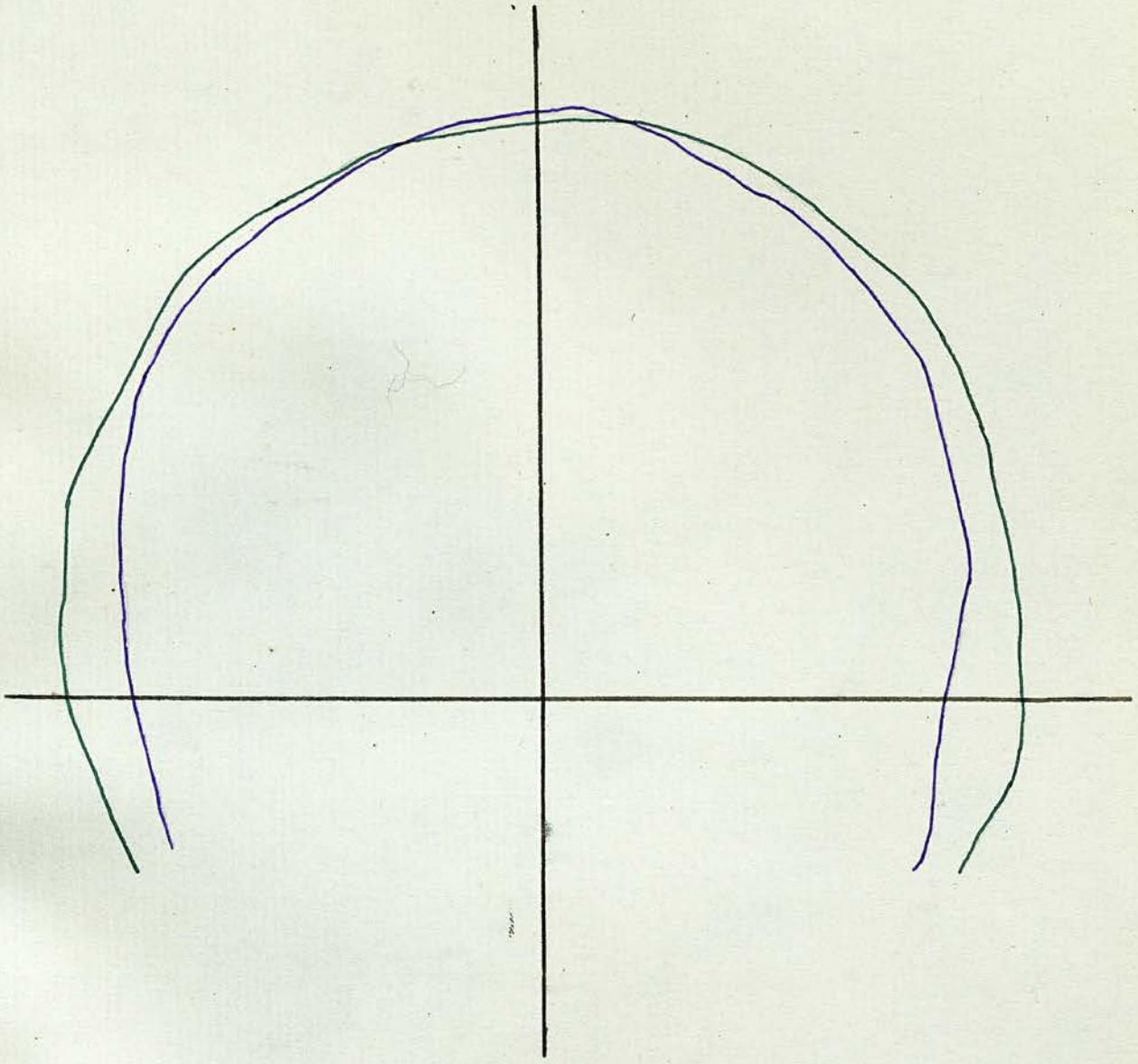
Scotch, 70.55.

Australian, 67.72.

Of course /

Of course all the skulls do not show such a graduated ratio between the measurements as is here shown, take for instance the average figures for the Maori skull. It has a narrower interspinous measurement than the Scotch and a wider measurement at the infra-temporal ridge, so that it might be more accurate to say that the two latter measurements do not seem to be influenced to such an extent by the altering conditions elsewhere in the skull. Further support for this statement is afforded by the tracings on pages 103,104. These are the mean coronal tracings obtained from the English and Australian skulls in the manner already described. The larger tracings are taken at the level of the external auditory meatus, and the smaller, at the narrowest part of the infra-temporal ridge. It will be seen that at the meatus the increase in width of the Scotch over the Australian is maintained throughout the whole tracing, and that in the tracing at the level of the infra-temporal crest, while the Scottish skull is much wider in the cranial portion, yet at the base the width is in both cases practically the same.
Lastly in regard to the width of the basi-occipital, difficulties arise in the measuring of this due to its irregularities in the formation of the bone and to the lack of any definite and constant points from which to take the measurements; so that whatever points are taken must be more or less arbitrary. It has been thought best to confine the measurements to two, the first, which may be called the greatest breadth is taken between the inner edges of the jugular foramina,

the

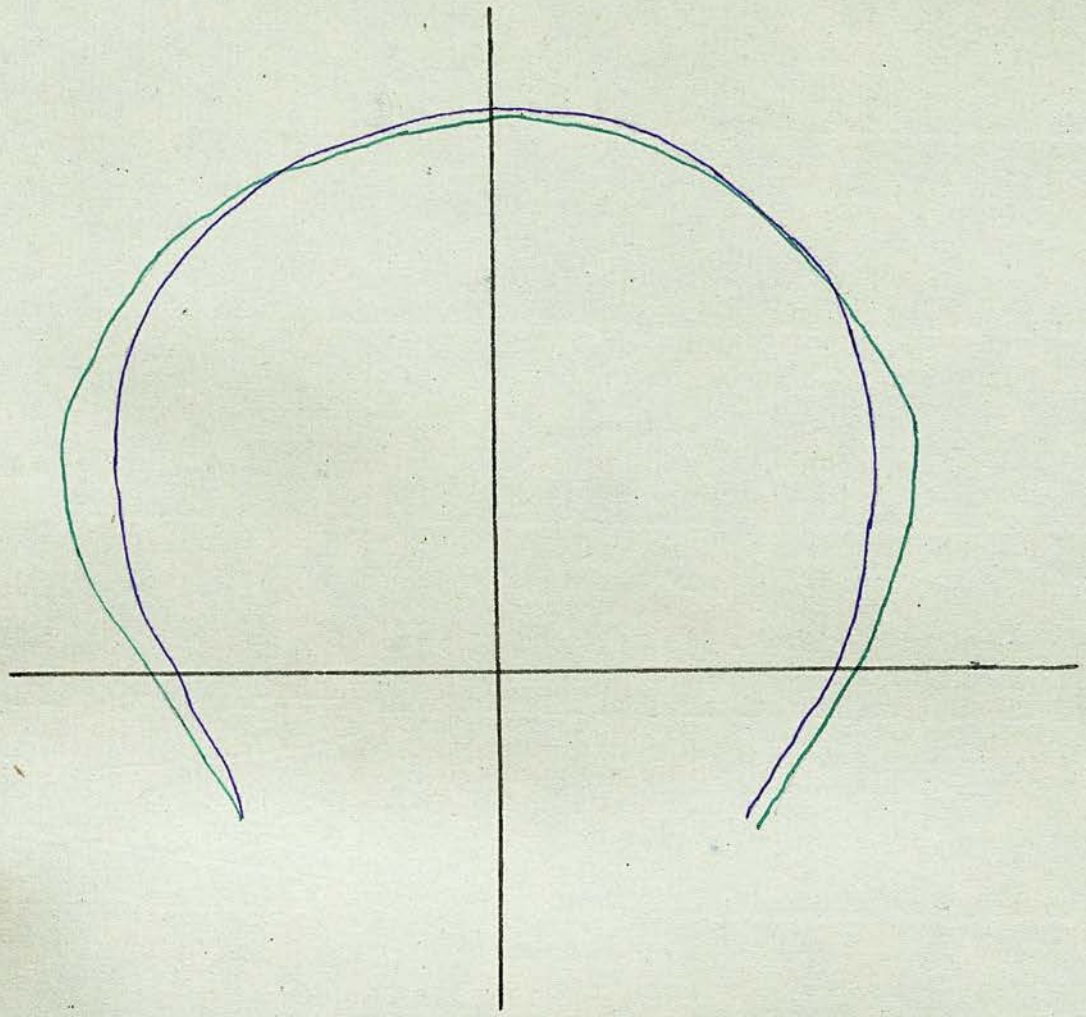


Mean Coronal tracings at external auditory meatus.

Green - Scotch.

Violet - Australian.

Fig. 15.



Mean Coronal tracings at infra temporal ridge.

Green - Scotch.

Violet - Australian.

Fig. 16.

the second, the narrowest, is taken at the narrowest part of the bone. The actual figures for these measurements are given on page 106 . The table shows that there is a difference in the widest measurement among all the skulls of 10 millimetres, the Scotch having the highest figure of 48.7 and the Bush the smallest with 38.14. Between these the other skulls group themselves more or less characteristically, the higher skulls tending to have a higher figure than the lower ones. Something of the same thing is seen in the figures for the narrowest measurement, though it is not so definite.

As the length of the basi-occipital is not available it is not possible to draw a comparison as to the relative proportion in the various skulls between the length and the breadth. However the distance from the vomer to the basion has been taken instead. A comparison between this measurement and the breadth of the basi occipital would give us quite as accurate information as regards the part under discussion as would be obtained from the use of the actual length of the basi occipital. This is evident because any variation of the basi occipital must be included in the length between the vomer and the basion, and although it may be objected that the distance from the vomer to the basion may deviate without any reference to the basi occipital, this is met by saying that it is not so much a matter of the basi occipital as of the whole region.

The proportion between the two measurements is given

on

	Greatest Width of basi-occipital.	Narrowest Width of basi-occipital.	Vomer to basion.	Index.
Scotch	48.7 m.	22.6 m.	28. m.	57.91.
Eskimo	46.23	22.53	33.07	77.1
English	45.70	21.4	28.2	61.48
Burmese	44.5	21.9	30.	67.41
Moriori	44.46	19.53	31.8	71.52
Chinese	44.92	20.61	28.61	63.69
Maori	44.2	19.7	31.1	70.36
N.A.Indian	44.11	22.2	30.1	68.23
Sandwich Is.	43.6	20.7	31.4	70.01
Bengali	43.6	22.1	30.4	69.72
Malay Penins.	43.3	20.7	30.5	70.43
Tasmanian	42.14	21.5	30.85	73.2
Negro	41	20.3	32.32	78.82
Admirality	40.8	19.1	28	68.62
New Guinea	40.3	19.8	29.5	73.44
New Caledonian	40.2	19.9	30.36	75.52
Bush	38.14	18.85	28	73.41
Australian	40.3	21.3	30.24	75.03
Gorilla	148		195	131.08
Chimpanzee	61		84	107.06
Orang	133		143	137.7

Table No.15.

on page 108 and it is apparent that there is a wide range of variation. The lowest figure 57 belongs to the Scotch, next to this come the English, Burmese, Chinese and North American Indian, while at the other end are the Australian, New Caledonian, New Guinea, Negro and Eskimo skulls. This is quite in accordance with what has been found elsewhere : that in the higher skulls the tendency has been for the base to become broader and shorter as compared with the lower skulls.

SUMMARY AND CONCLUSION.

In the lower skulls the bones of the base are characterised by their thickness, density and greater strength as compared with the bones of the higher skulls.
In the lower skulls the growth of the bones is a much more predominant feature and is carried to a far greater extent than in the higher skulls, so that all the boney fomamina in the base are smaller and less open in the former than in the latter ; and in the lower skulls the boney ridges are much better developed than in the higher : these points are particularly seen in reference to the under surface of the petrous temporal bone. This difference however, cannot perhaps be regarded as peculiar to the base as distinct from the other parts of the skull because they may just, and undoubtedly do, partake of the characters which are distinctive of each type of skull as a whole.
It is when the relative measurements of length and breadth are dealt with that differences peculiar to the base itself can be recognised, and the differences which belong to the base itself appreciated. As we trace the development of the skull from the lower to the higher types we find the following changes taking place. First of all the petrous part of the temporal comes to lie more transversely to the middle line of the skull, the actual angle made by the two axes of the bone where they meet in the middle line ranging from 90° in the lower skulls to 96° in the higher. The length of the nasion-basion line tends to become shorter. The basi-occipital becomes set at a greater slope to the

horizontal/

horizontal plane through the basion. The distance from the vomer to the basion becomes shorter. The proportion between the length and breadth of the base shows a gradual change by which the base becomes relatively broader as we trace it upwards ; the relative increase in width being more apparent in the more centrally situated part of the base, i.e. in the region corresponding to a line through the stylo-mastoid foramina. It can be said therefore that as a general rule the characters of the base partake to a greater or lesser extent of the characters of the vault; the long, narrow skull having a comparatively long, narrow base and the broad skull having a corresponding broad base.
It follows from this then that the factors which produce an increase in the total width of the skull also operate on the base producing a corresponding widening here. This opens up the whole question of the relation of breadth of skull and mental capacity, but a discussion of this very wide subject is outside the limits of this paper. It will be sufficient to point out that the conclusions which have been arrived at amply support the view that increase in width of the skull is commensurate with increase in intelligence; but further than this it would appear that the width of the skull when taken as a measure of the mental capacity should not be confined merely to the widest diameter of the cranial vault nor even to the proportion between it and the greatest length as expressed by the cephalic index; but that attention should also be directed to the width of the base because it is quite

conceivable/

conceivable that a skull may possess a wide inter-parietal width and yet when the width is measured at the base this may be less than in a skull with a smaller inter-parietal width. A skull in other words that when judges by the ordinary methods is brachy-cephalic in character and therefore presumably of a high standard intellectually, but when judged by its basal measurements is seen to possess characters allying it rather with the lower forms.

Consequently we can only re-affirm the statement that the expression of the greatest length and breadth of a skull does not necessarily characterize it. Two skulls may agree approximately in these features yet differ absolutely in shape, degree of development, and in what affects us here more particularly, in their basal measurements.

Take for instance the average figures for the Scotch and Moriori skulls in this connection. These are the two that approach each other most nearly in respect of these measurements.

	Greatest length.	Greatest breadth.	Cephalic Index.
Scotch,	184 m.	143.85 m.	78.7.
Moriori,	186.53m.	140.86m.	75.5.

	Breadth at Stylo mastoid foramina.	Length of basi nasal line.	% age proportion.
Scotch,	84.34 m.	97 m.	58.63.
Moriori,	82.6 m.	104.6 m.	78.92.

While they are not separated widely in respect of the cephalic index yet when they are compared in respect

of /

of the propertion between the length and breadth of the base the difference is very marked: a much greater difference separating them here than in the cephalic index. Or take the Malay skull and the Scotch. The Malay has a greater cephalic index than the Scotch. Yet the figure denoting the index between the length and breadth of the base is lower.

	C.I.	% age proportion between length and breadth of base.
Malay,	79.18	81.11.
Scotch,	78.17	86.96.

The same thing occurs with the Burmese and Scotch.

Burmese,	80.7	85.65.
Scotch,	78.17	86.96.

Comparing these with the low grade Australian we get.

Australian	70.42	78.72.

It might be quite possible to regard such skulls as the Malay and Burmese, where the interparietal width is very wide, but where the base does not partake of the broad element to such a degree, as an imperfect or crude form of brachycephalism thus applying that the true type of brachycephalism is to be found in such skulls as the English and Scotch where the brachy-cephalic character is seen also in the measurements of the base .

I have investigated this point in regard to a series of foetal skulls and the results are interesting. The actual figures obtained are given on page 112. It will be seen that the average cephalic index for

the /

Foetal Skulls

	Length.	Breadth.	Nasion basion	Breadth at stylo mastoid foramina.
I.	I06m	89 m	57 m	42 m
2.	95	79	50	37
3.	I08	86	57	44
4.	I06	87	55	46
5.	I09	86	55	42
6.	II9	I07	64	48
Average	I07.I5 m	89 m	56.33 m	43.I5 m

Cephalic Index = 83.06

Basal Index = 76.60

Table No.16.

the seven skulls is 83.06 ; while the basal index is 76.60 , a comparison of these figures with the corresponding ones for adult skulls given on page 96 shows that while the figures representing the cephalic index exceed that for the most brachy-cephalic skull in the series, yet the figures for the per centage proportion between the basal measurements comes much short of the lowest corresponding figure in the adult. Thus the Burmese skull has the highest cephalic index of 80.7 and the Australian has the lowest basal index of 78.72. Of course figures got from dried foetal skulls must always be received with caution but I think that their comparative value here is clear and they can be accepted as illustrating the condition.

These figures lend support to what has been said before in connection with the Malay and Burmese skulls. They would further indicate that the narrow base, or perhaps it would be better to say the comparatively narrow base, expressed as a percentage between the length and breadth belongs to a primitive and early type of skull and that the broader base is a later development coincident with the widening of the cranial vault and increase in cranial capacity and intellectual attainment.

Consequently more accurate information as regards the degree of mental capacity would seem to be obtained from a study of the base measurements than that obtained from measurements taken of the greatest diameters of the cranial cavity.

Finally I present for the purposes of comparison the

mean /

mean tracings obtained from the different skulls.
The chief interest from the point of view of this paper attaches itself to the fact that we are able to obtain at a glance the salient points of the skull as seen in the various tracings, and to associate these with the characters of the base which we have just been considering.
From out of the whole series of skulls three groups have been selected, each group being fairly typical of the type to which it belongs. Thses are the Australian the Scotch and the Burmese. On page 119 the sagittal tracing is shewn for each of these groups, they have been super-imposed in such a way that the basion and the direction of the nasion basion line are co-incident in each case.
We find illustrated very well here many of the typical features of these skulls: the wider frontal eminence of the Scotch and Burmese than in the Australian : the decrease in the height of the Scotch skull : the great increase backwards and downwards of the occipital region in the Scotch as compared with the Burmese and Australian : the comparatively short length of the Burmese and the greater height : the gradual decrease in the amount of prognathism : the shortening of the basi-nasal line : the increased slope of the basi-occipital.
Although it is strictly outside the bounds of this paper it is interesting to glance for a moment at one or two points brought out by these tracings. First as to the difference in the frontal region, this

appears /

appears to be very much less than what one might have expected, as a matter of fact though while handling the individual Scotch skulls I was struck with the fact that in the large majority of those examined the bold frontal curve which one looks to as characteristic of the higher skulls was entirely absent , and that many of the Australian skulls were, to the eye at least, in no way inferior to them in this respect.

Certainly if we are to regard the tracing as a true picture of the state of affairs, then we must conclude that the growth in the frontal region does not take place to the extent that we have been accustomed to credit.

We must remember however that we are only dealing with the longitudinal tracing and that growth may have taken place in this region, as indeed we know it has, in the lateral direction, so that very considerable growth may have taken place in the frontal region without its being shown by a longitudinal tracing.

But the place where the greatest difference exists is in the occipital region, and here we find changes greater and much more evident than any that take place in the frontal region.

The whole occipital part of the skull has been expanded backwards and downwards far in excess of the other two skulls.

The change not only takes place in the longitudinal direction but also from side to side so that really the main characteristics of the Scotch skull is this great development of the Scotch skull. Owing to

want /

want of time at my disposal I have been unable to obtain coronal tracings of the occipital region to illustrate this point. To obtain tracings of this region which would be of any value for comparative purposes necessitated a tedious and rather complicated proceedure to undertake which I had not the necessary time.

The question is this, how has this change come about ? does it depend on what we might call internal forces or external forces ? by this I mean is this backward and downward expansion due to an increase in the brain substance in this region or is it due to changes that have taken place elsewhere ?. For instance, comparing it with the Australian skull the height has decreased and the sphero ethmoidal angle has been diminished in such a way that the bones of the face have, as it were, been thrust backward into the base of the skull; according to crude physical laws, a combination of forces producing these two changes would tend to have one effect, i.e. to bulge the occipital region. Of course this question cannot be discussed without taking into consideration the capacity of the skull. We know that the Scotch skull has a much greater capacity than the Australian, and this can only be accounted for by a corresponding increase in the amount of brain substance. But whether this increase in capacity is due to a general increase in the growth of the brain all over or to local expansion, either frontal or occipital, or which of these factors it is which predominate we do not

seem to have any means to discover. Certainly whatever be the cause of it, it would seem to be typical of this class of skulls. The tracing for the English skull approximates it very closely; with this exception, no other skull in the whole series shows the same feature. I do not say that the character is peculiar to the Scotch skull: the English skulls share it equally with the Scotch. What one can go the length of saying is that this expansion in the occipital region is characteristic of a high grade mesaticephalic skull, because when the skull becomes distinctly brachycephalic the tendency is for the length to be shortened and for the occipital region to assume the form which is seen in the Burmese skull.

As to the coronal tracings obtained from these three groups of skulls these are shown also on pages 120 & 121. In the tracings at the level of the meatus the differences are well seen. The Scotch skull is the broadest and lowest, the greatest breadth in the Scotch skull is low down in the region of the temporal bone, it is placed higher up in the Burmese and higher still in the Australian, this merely demonstrates the well known fact that in the lower skulls it is generally found lower down nearer the base.

Much the same things are found in the tracings at the infra temporal ridge. The Scotch has the greatest width and the least height. One point however that deserves notice is the slight difference that exists between the tracings at the base: this has already been referred to above and it would seem from this that at

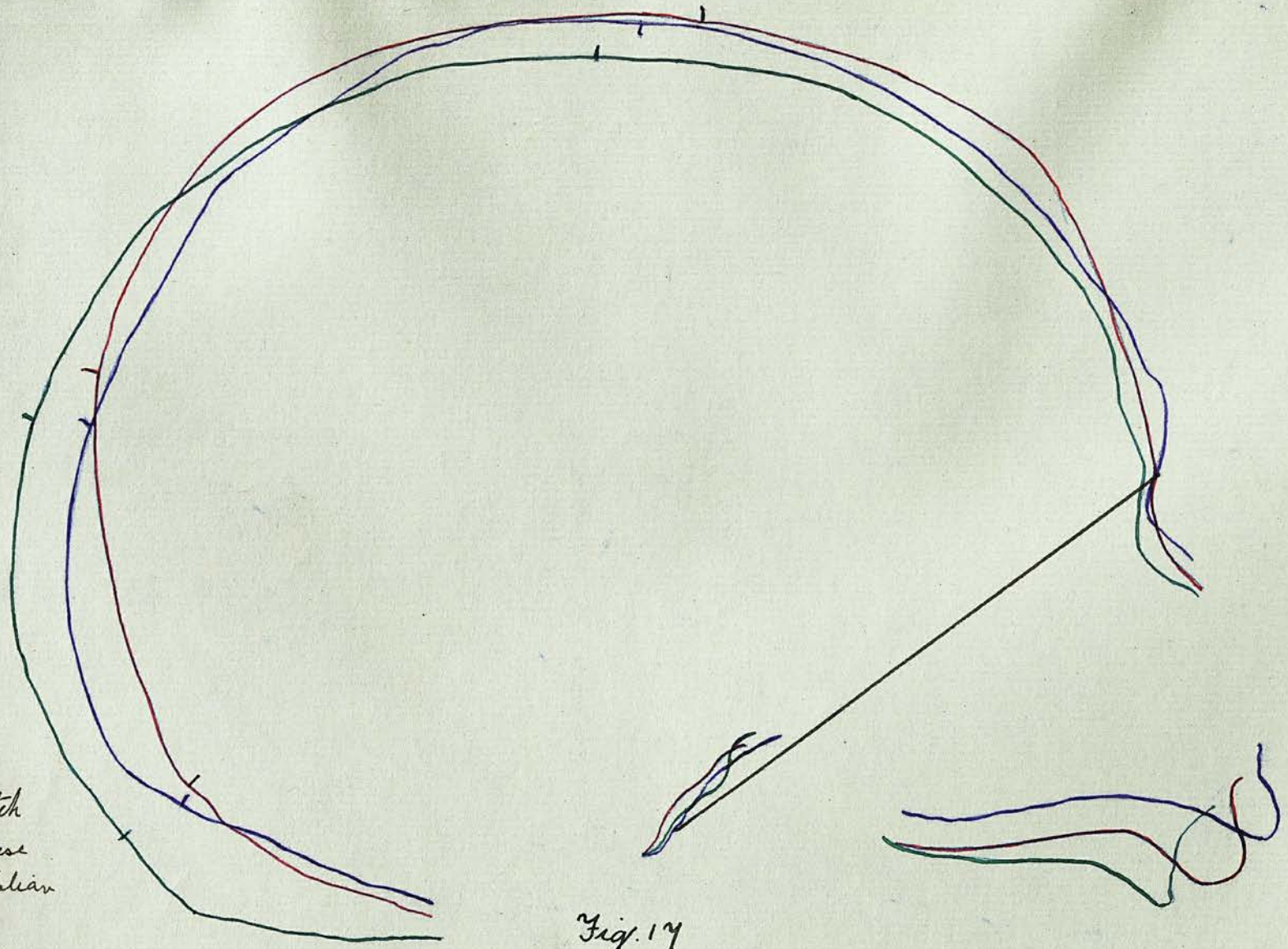
this /

this part there is less variation from the type in the width of the base than at the level of the meatus, even though there may be a comparatively wide range of variation in the vault.

On page 122 is given the diagrams representing the basal measurements for the three groups A B is the interstylo-mastoid width and the angle A C B is the angle at which the petro mastoid bone is set to the middle line of the skull. It must be remembered though that this diagram is constructed taking the interstylo-mastoid width as 100. For comparisons sake I have inserted the corresponding figure for the chimpanzee.

It will be seen that the angle for the Scotch is 95^{o} for the Burmese 96^{o} for the Australian 90^{o} and for the chimpanzee 66^{o}.

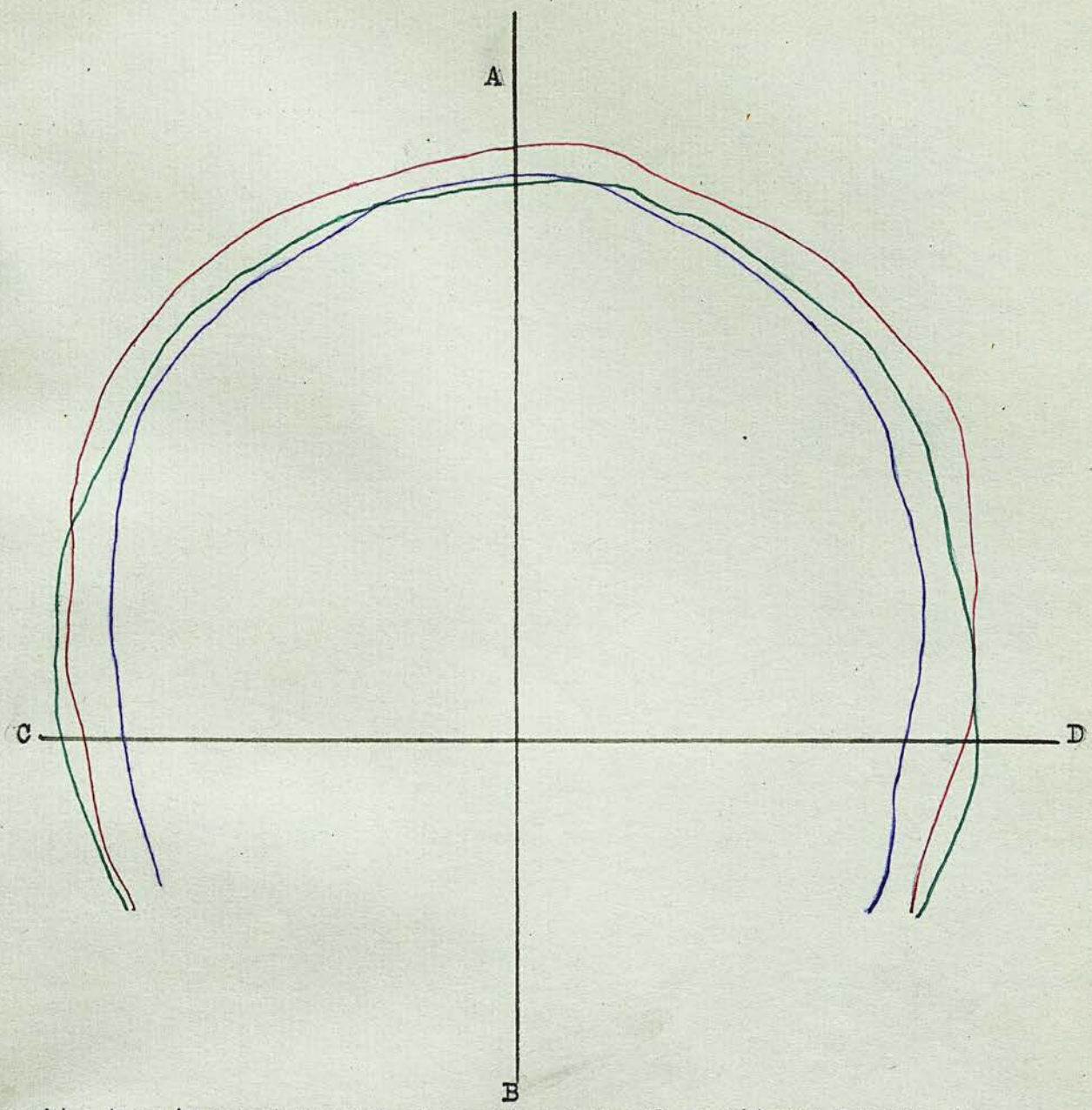
I have not endeavoured to demonstrate anything like a close association between the various tracings for all the groups of skulls - still less to shew that for each particular tracing in one direction there is a corresponding one in another direction. To do any such thing would be , I consider, futile. All I have hoped to do is to shew from a consideration of a series of skulls drawn from all sources , many of them possessing very similar characteristics, others shewing wide differences, that as the general shape and form of the skull changes in its ascent from the lower type to the higher so also are changes of a similar nature to be seen in the basal region of the skull.



Green. – Scotch
Red. – Burmese
Violet – Australian

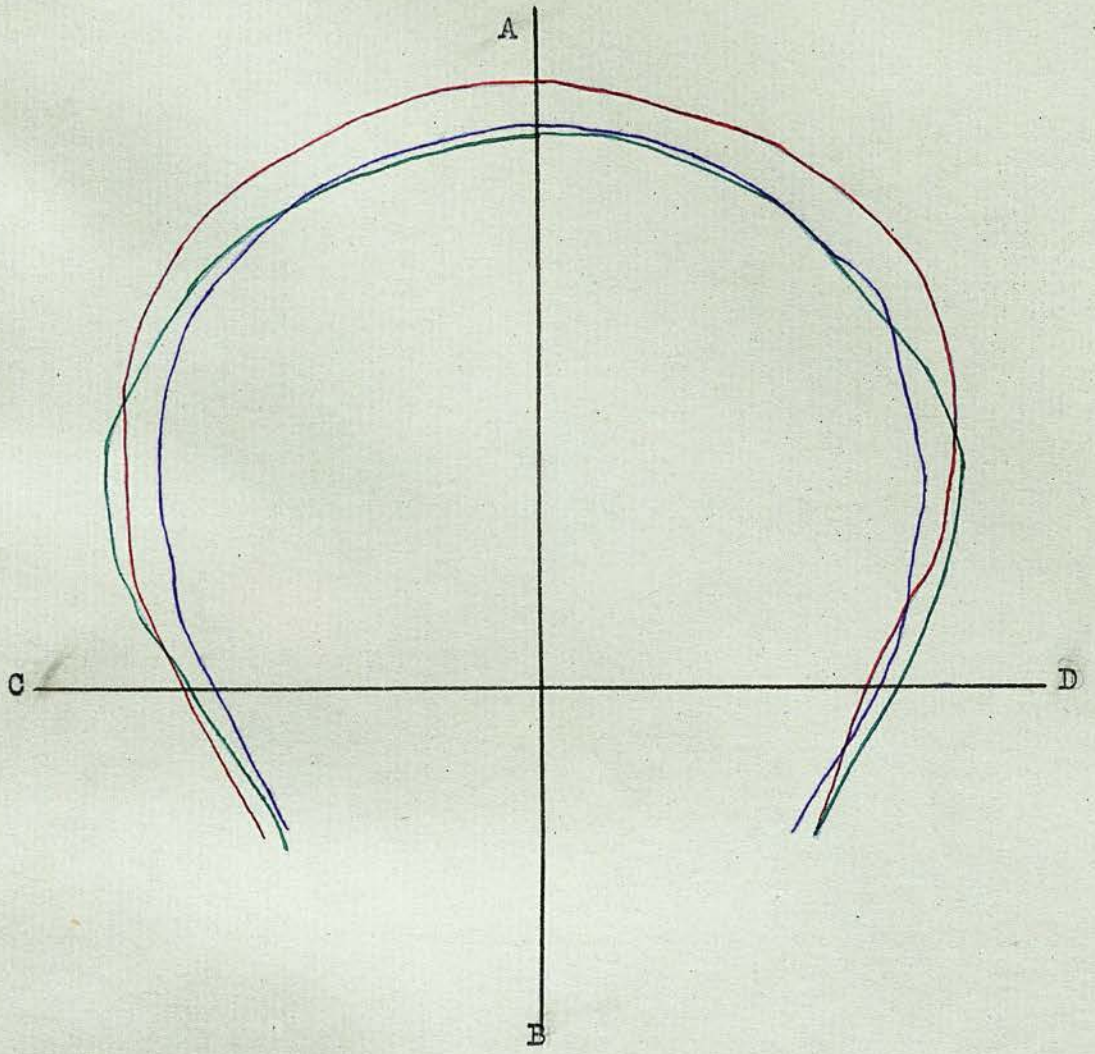
Fig. 14

Illustrates in the Scotch the decrease in height, the backward, and downward expansion in the occipital region: the shortening of the cranio-facial ; the increase in the slope of the basi occipital + the diminution in the projection of the jaw.



Composite tracings at upper edge of external auditory meatus the skull being placed so that the nasion basion line was at 27° to the perpendicular.
A.B.= Sagittal plane.
C.D.= Horizontal plane at 27° to the nasion basion line though nasion.
Green Scotch.
Red Burmese.
Violet Australian.

Fig. 18.

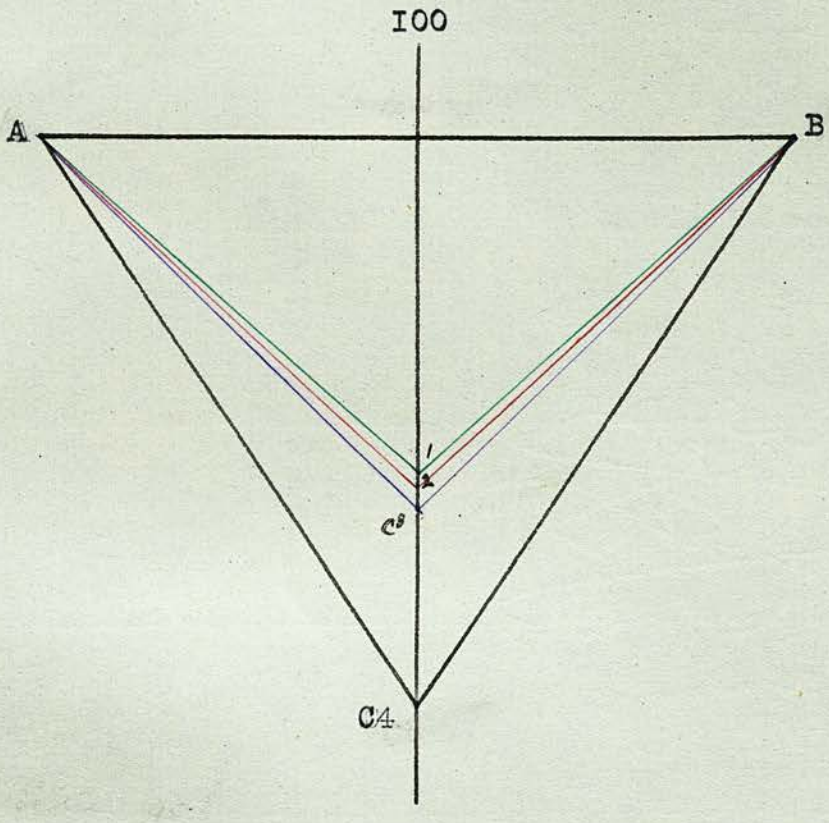


Composite coronal tracings at infra temporal ridge.

Skull at 27° to the perpendicular.

Green	Scotch.
Red	Burmese.
Violet	Australian.

Fig. 19.



Green	English & Scotch	95°
Red	Burmese	96°
Violet	Australian	90°
Black	Chimpanzee	66°

Fig. 20.

Appendix.

Tables of Measurements for the individual skulls in each group.

All measurements are in millimetres.

Cat. No 28·C	Length							Width						Thickness	
	Glabella to Greatest	Glabella to Inion	Nasion to Greatest	Nasion to Inion	Nasion to Basion	Nasion to Vertex	Vertex to Basion	at Sphenoid at opisthotemporal ridge		Greatest at post. root of Zygoma.	Inter Meatal	at Stylo mastoid foramina	Inter Auricular	Basi Bregmatic	
1552	183	170	181	166	102	70	32	73	67	145	132	106	84	115	129
2	189	175	185	170	106	74	31	70	70	138	125	111	83	122	134
5	190	172	190	169	100	69	31	76	73	145	125	108	81	124	134
6	189	179	185	171	107	76	31	70	67	135	120	102	82	117	132
8	184	174	182	168	102	71	31	71	68	147	127	113	84	128	142
10	190	177	187	173	103	70	33	70	67	143	126	100	88	121	135
11	192	173	182	171	103	75	29	74	70	142	125	103	85	120	131
12	187	176	184	170	110	75	35	75	66	134	130	106	84·5	122	128
13	184	177	183	170	105	75	30	73	72	143	130	107	85	122	134
14	193	182	192	173	112	80	32	78	72	145	134	117	87·5	131	140
15	193	183	190	177	107	77	31	71	68	140	130	111	85	123	138
16	172	160	172	156	101	66	36	71	68	135	124	104	83	114	129
17	191	177	187	169	105	76	32	74	67	146	133	111	83	126	140
18	189	183	182	175	108	76	33	73	66	139	129	104	82	125	137
7	182	165	177	159	100	69	31	67	67	136	130	100	77	119	134

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Chatham Islands.

Moriori.

Cat. No	Length							Width				Height			
	Glabella Greatest	Glabella to Inion	Nasion to Greatest	Nasion to Inion	Nasion to basion	Nasion to Vomer	Vomer to Nasion	Greatest	Inter Mastoid	at Spine	at post root of Zygoma	at Infra temporal ridge	at Supra Nasion	Inter Auricular	Basi Bregmatic
8	176	169	176	165	97	67	30	126	100.	74	119	63	78	128	117
3	184	176	181	169	96	70	25	130	97	67	114	64	75	132	121
5	185	165	181	160	95	62	30	129	90	68	112	64	76	138	124
6	183	175	178	168	101	70	30	134	97	69	118	64	77	140	124
7	184	178	183	175	98	68	31	125	88	65	116	64	73	120	114
28	169	164	165	157	94	70	24	119	90	70	110	61	76	126	111
9	178	177	175	172	98	69	29	123	92	63	106	61	71	129	117
10	184	174	184	172	95	68	26	130	100	70	118	67	80	132	124
11	175	161	174	155	90	64	24	123	89	62	118	63	76	122	112
14	175	174	173	171	102	72	31	140	110	73	127	67	81	134	118

Admiralty Islands.

Cat No	Length								Width						Height	
	Glabella. Greatest	Glabella. Incisor	Incisor Greatest	Incisor to Incisor	Incisor to Basion	Incisor to Vomer	Vomer to Basion	Greatest	Inter Meatal	at digastric at post. maxillo root of Zygoma	at Apex of Sphenoid	at infra temporal Crest	Inter Auricular	Basi Bregmatic		
28. H	4	174	170	173	165	99	69	30	125	112	77·5	114	67	72	133	122
	5	192	175	190	169	98	73	27	129	97	81	114	70	66	143	133
	6	184	165	183	161	98	65	33	128	112	75	114	66	61	135	123
	7	175	165	173	160	100	71	20	137	104	84	120	72	66	134	122
	9	182	175	178	168	100	71	30	126	98	80	110	68	55	133	120
	10	200	185	195	179	104	74	30.	141	111	84	103	73	70	143	129
	2	179	164	175	160	88	59	31	130	92	77	118	65	64	126	118
	14	190	184	184	176	101	69	32	128	104	84	117	70	66	146	125
	3	180	165	176	160	98	68	30	122	88	75	117	65	67	132	121
	12	197	192	194	185	110	77	34	138	114	82	118	66	66	147	130
	11	183	173	176	165	93	66	27	135	95	72	117	54	66	140	125

New Caledonian

		Length							Width						Height
Cat. No.		Glabella to Greatest	Glabella to Incion	Basion to Greatest	Basion to Incion	Basion to Basion	Basion to Vomer	Vomer to Basion	Greatest Meatal	Inter Meatal	at Spenic of Sphenoid	at post. root of Zygoma	at Infra Temp. ridge	Basi Bregmatic	Inter Auricular
21. K	4	171	160	168	155	94	68	26	142	102	75	122	71	132	122
	6	180	174	179	171	99	73	26	148	111	79	129	75	139	128
	7	178	171	176	166	106	71	35	130	112	73	127	71	141	125
	8	181	181	178	177	102	74	28	135	102	73	121	70	135	121
	9	174	173	172	168	102	71	32	138	102	74	127	75	135	123
	11	161	161	155	155	99	70	29	144	111	76	110	72	135	120
	12	168	164	166	162	96	64	32	131	97	71	120	73	131	118
	13	182	167	182	165	100	70	30	143	97	73	130	69	141	125
	18	172	172	169	165	101	70	31	139	108	76	132	70	138	121
	19	174	174	168	168	105	74	31	149	111	79	128	76	137	125

Burmese

	Length							Width						Height	
Cat No	Glabella to Greatest	Glabella to Incisor	Nasion to Greatest	Nasion to Incisor	Nasion to Basion	Nasion to Vomer	Vomer to Nasion	Inter orbital Greatest	Inter orbital at apex of Sphenoid	Inter orbital at post root of Zygoma	Inter orbital at Infra temporal ridge	Inter orbital at Glabella	Nasion to Alveolar	Nasion to Basion
1622	186	174	182	167	99	77	30	131	99	70	115	70	80	131	118
1620	172	168	169	163	97	67	30	120	91	66	104	59	75	130	111
1619	169	158	160	149	90	63	27	119	90	63	110	62	71	123	114
1618	193	187	185	178	109	76	33	127	101	73	117	69	80	143	127
1617	170	164	169	160	99	70	30	120	96	65	111	68	74	123	112
1616	178	169	174	159	96	65	31	129	94	66	108	66	75	138	118
1615	172	163	168	156	94	68	26	121	96	63	113	66	74.5	128	113
1614	170	156	167	149	92	63	31	134	85	62	116	63	73	137	121
1613	187	180	182	173	106	74	32	131	103	68	119	72	82	140	124
1612	181	178	168	169	103	72	31	126	106	72	119	71	84	139	118
1611	170	160	186	159	99	69	30	123	95	70	112	69	76.5	132	113
1610	178	174	172	164	100	73	28	126	98	68	114	68	76	134	118
1609	189	187	182	179	109	73	36	128	109	68	121	69	80	138	116
1608	176	168	170	160	92	63	29	123	90	65	107	63	76	130	119
1607	188	179	183	172	104	71	34	126	97	67	109	68	80.5	134	116
1606	185	182	180	176	104	75	30	134	101	72	121	66	80.5	145	128
1605	168	157	166	154	97	63	34	126	95	60	113	64	77	131	115
1604	182	173	175	164	98	68	31	130	91	65	113	61	75	133	115
1603	176	167	174	162	100	70	30	122	97	65	109	70	76	130	117

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Australasian

Cat. No.	Length							Width						Height	
	Glabella to Greatest	Glabella to Inion	Nasion to Greatest	Nasion to Inion	Nasion to Basion	Nasion to Vomer	Vomer to Basion	Greatest	Inter. Meatal	at Stylo mastoid foramina	at post root of Zygoma	at Spine of Sphenoid	at Infra temporal ridge	Inter Auricul	Basi Prognathic
1376	179	176	177	169	100	68	32	127	102	82·5	114	69	67	135	114*
1358	176	171	171	164	101	71	30	131	100	85	123	72	71	138	123
1361	181	175	179	172	100	73	27	126	93	76	110	66	64	130	112
1377	183	173	178	163	101	72	31	128	97	78	107	65	66	130	115
1380	181	173	178	168	100	72	29	120	91	79·5	112	73	65	129	114
1384	188	184	183	177	106	72	34	130	102	81	115	69	71	136	122
1374	184	177	181	171	101	72	30	128	98	78	112	68	64	140	124
1375	184	180	179	174	100	72	29	128	101	86	118	94	65	133	114
1252	186	182	183	177	102	73	30	124	100	79	114	71	68	132	117
1367	177	175	171	169	105	73	33	130	96	80	115	65	72	146	122
1254	197	191	193	184	108	75	34	127	102	84·5	121	75	69	138	119
1366	191	185	186	178	108	77	32	130	101	75·5	121	73	68	136	121
1404	195	189	190	182	110	79	31	133	107	90	111	80	69	139	120
1405	174	166	172	159	95	66	29	132	91	78	120	68	65	125	118
1526	184	174	180	169	95	67	28	132	102	78·5	110	70	73	126	112
1269	182	172	177	166	102	72	30	141	98	75	124	69	72	138	122
1267	177	171	175	167	100	70	30	131	94	78	112	66	64	132	120
1266	186	183	186	175	97	70	29	132	100	81	122	70	67	128	119
1622	186	174	182	168	99	70	30	130	100	79	119	70	63	132	119

Australian (etc)

Cat. No.	Length: Glabella–Greatest	Glabella–Inion	Zygomaxillare–Greatest	Zygomaxillare–Inion	Nasion–Basion	Zygion–Vertex	Zygion–Basion	Width: Greatest	Interauricular	at Sphenoid	at Temporal root	at Zygoma	at Stylomastoid foramina	Height: Interauricular	Basion–Bregmatic
1602	177	172	169	164	101	69	34	120	93	63	66	105	76	135	116
1601	171	162	169	155	93	66	27	137	101	70	70	118	79	136	118
1365	185	184	179	176	102	71	31	127	103	68	70	116	79	131	121
1586	192	176	183	165	96	67	29	125	102	67	64	113	78	136	121
1585	188	172	185	166	97	66	32	135	97	70	72	123	82	135	123
1600	170	163	167	156	93	60	34	123	91	67	67	113	76.5	125	113
1584	187	177	182	168	104	75	30	127	102	73	73	118	83	141	124
1553	179	170	173	162	92	63	27	125	95	63	65	116	72	121	116
1412	181	176	176	170	95	72	27	134	97	67	73	105	75.5	125	112
1363	194	182	179	176	109	77	33	129	104	83	74	122	72	134	114
1389	199	183	194	174	104	73	31	142	105	81	69	106	73	131	118
1409	185	176	181	169	95	68	27	145	97	79	76	110	73	130	121
1410	193	184	188	177	103	72	31	129	93	80	69	113	70	137	122
1270	186	182	183	176	99	71	28	125	87	76	65	114	65	132	120
1368	185	180	182	176	102	74	28	130	95	79	67	107	66	135	119
1411	187	168	175	163	100	72	28	136	109	84	71	119	77	130	118
1412	183	176	180	171	95	67	28	129	103	84	75	120	66	123	116
1360	180	179	175	173	97	68	30	124	99	82	70	112	66	136	116
1381	185	177	180	171	107	78	30	123	96	79	70	117	67	133	117
1362	181	175	177	169	98	69	30	130	100	75	67	118	65	133	120

Australian (Ctd.)

Cat. No.	Length: Glabella to Greatest	Glabella to Incisors	Nasion to Greatest	Nasion to Incisors	Nasion to Basion	Nasion to Vomer	Vomer to Basion	Greatest Interal	Inter. Mastoid	Width: at sphenoid at Zygoma	at Infra Temp. ridge at root of Zygoma	Height: at Sphenoid	Inter. Auricula	Basi Bregmatic	Breadth at Stylo. Foramina
X X 1. A2	170	160	171	156	94	65	29	133	92	74	68	69	117	131	83
3	182	172	179	170	98	69	31	132	95	69	119	64	121	130	81
5	177	164	177	161	92	66	26	135	94	67	115	70	121	132	82
9	164	156	164	155	96	68	28	136	90	68	110	68	115	129	80
11	181	174	179	120	103	72	32	121	99	69 (1)	114	63	120	138	80
12	176	167	175	162	100	67	33	131	99	70	109	61	119	133	80
15	181	179	177	173	97	66	31	129	100	71	115	72	114.	128	83
17	177	165	172	160	101	71	30	150	106	72	121	69	123	136	85
22	188	174	181	166	100	69	31	135	105	70	115	75	124	135	55
24	172	169	168	160	98	65	33	135	106	75	122	71	121	140	90

Bengali

	Length							Width					Height		
Cat. No. 22.B	Glabella Greatest	Glabella to Incor.	Nasion Greatest	Nasion to Incor.	Nasion to Basion	Nasion to Vomer	Vomer to Basion	Greatest Intermeatal	Inter. at Sphenoid	at Sphen. & Zygoma	at post root of temporal	at Infra ridge	Basi Bregmatic	Inter Auricular	Width at Stylo Maxillo Jugamic
3	168	161	167	159	91	64	27	144	102	72	130	72	126	116	82
4	186	180	185	175	100	73	27	147	105	70	135	71	135	125	84
5	175	168	175	164	97	68	29	152	103	75	134	68	130	119	83
10	170	160	170	155	92	65	27	140	102	72	128	71	128	112	83
13	182	176	176	170	106	72	33	146	113	78	132	80	145	129	89
15	177	172	174	168	105	73	32	140	100	75	127	72	142	129	86
17	173	170	171	166	93	64	28	138	100	70	121	69	129	117	76
18	175	173	174	170	103	75	30	138	104	72	126	74	135	119	84
27	167	158	168	156	101	65	36	130	95	64	120	74	133	117	79
31	182	170	178	170	107	74	32	138	110	77	129	77	147	128	91

North American Indian.

	Length							Width						Height	
Cat No.	Glabella – Greatest	Glabella to Incai	Nasion – Greatest	Nasion to Inion	Nasion to Basion	Nasion to Vertex	Vertex to Basion	Greatest	Inter meatal	at Stylo mastoid foramen	at Post root of Zygoma	at Spinous process of temporal	at Supra Stephanoid ridge	Inter Auricular	Basi Bregmatic
1. B 19	188	176	185	185	96	70	26	139	101	82	117	72	73	133	122
57	187	175	186	173	100	70	30	142	104	83	121	71	66	135	121
64	200	188	198	184	105	73	32	147	102	91·5	128	72	73	143	128
94	174	172	169	166	94	66	28	139	105	70	124	69	67	136	120
114	175	173	171	168	98	70	28	148	100	86	124	69	75	128	111
115	191	186	188	185	107	78	29	157	117	91	140	78	87	128	120
116	179	174	176	169	97	72	25	151	104	95	135	81	76	133	116
118	186	175	186	170	100	*69	31	148	115	93	130	77	73	127	115
119	187	179	181	171	95	68	26	158	115	87	130	73	72	124	124
120	179	172	178	170	99	–	–	152	102	87·5	133	78	71	127	121
125	180	164	178	160	91	97	28	143	97	76	121	72	68	120	110
153	185	174	185	170	97	72	25	121	89	72·5	117	70	63	123	119
156	172	156	171	153	96	66	30	137	98	84·5	120	72	71	122	110
158	178	166	175	163	99	62	30	14–	97	83	123	72	76	134	119
162	182	170	178	163	*86	62	26	141	98	81	116	68	68	131	118
163	185	177	182	170	96	98	28	138	97	82	127	68	65	135	122
170	189	181	182	175	101	70	31	141	102	82	118	68	68	130	117
175	189	176	186	167	102	70	32	151	105	88	130	74	75	139	121
186	192	183	190	176	101	72	29	145	98	87	121	75	67	135	120
194	183	170	183	165	88	65	23	137	89	80	110	66	67	126	112

Scotch.

	Length							Width						Height	
Cat. No. 28. H	Glabella Greatest	Glabella to Incisi	Nasion to Greatest	Nasion to Incisi	Nasion to Basion	Nasion to Vomer	Vomer to Basion	Greatest	Inter meatal	at Stylo mastoid jouramina	at post root of Zygoma	at spine of Spheroid	at supra temporal ridge	Inter-auricular	Basi bregmatic
1	178	171	176	167	97	71	25	121	95	75	117	66	63	116	128
2	168	167	165	163	99	68	30	127	97	91	115	69	65	121	134
3	177	170	175	165	99	66	33	135	94	81	144	70	67	121	134
4	179	174	178	170	103	71	32	128	96	80	113	67	68	122	141
5	172	165	170	162	97	68	29	128	93	78	117	63	59	116	129
6	175	171	169	163	92	67	25	124	91	74	110	64	61	111	120
8	176	171	174	168	100	69	31	133	98	76	110	65	63	115	130
11	172	171	166	165	97	68	28	124	94	72	109	64	65	116	135
12	172	162	169	155	—	64	—	133	90	82	144	69	63	116	-
13	176	162	176	158	—	70	—	130	92	82	115	70	66	119	-
14	166	160	162	153	-	65	-	135	94	75	115	67	67	116	-
15	189	178	188	177	104	63	31	132	104	83	120	76	70	125	135
19	176	175	174	172	-	-	-	122	95	76	116	68	68	117	-
22	166	156	164	151	93	64	29	135	100	82	119	70	68	121	136
24	175	173	172	170	103	74	30	122	99	82	110	70	58	118	183
25	173	170	172	166	105	75	29	132	100	78	116	69	65	122	135

New Guinea

Cat No. 26 F	Length							Width						Height	
	Glabella — Greatest	Glabella to Incisi	Nasion — Greatest	Nasion to Incisi	Nasion to Basion	Nasion to Vomer	Vomer to Basion	Greatest	Inter Meatal	at Slight Nasford Jugum	at post root of Zygoma	at Spine of Sphenoid	at infra temporal ridge	Inter Auricular	Basi Bregmatic
2	180	179	178	173	100	71	29	129	87	66	110	73	71	139	124
4	177	173	177	172	95	64	30	136	90	67	109	75	72	125	117
5	190	181	187	176	104	71	33	148	103	72	125	90	71	142	120
6	188	176	185	171	103	69	34	133	99	69	115	79	75	140	131
7	199	197	198	196	114	79	35	132	112	71	117	83	69	137	120
8	176	173	174	169	101	70	32	129	112	71	118	85	68	139	123
12	188	179	188	175	108	73	35	133	102	73	125	82	70	145	130
17	185	179	185	176	107	75	32	139	102	80	127	86	77	135	120
18	180	177	177	171	105	76	30	141	117	75	124	87	71	131	118

Catalogue No.	Length: Glabella – Greatest	Glabella to Inion	Nasion – Greatest	Nasion to Inion	Nasion to Basion	Nasion to Vomer	Vomer to Basion	Width: Greatest	Inter-mastoid	at Stylo-foramen	at post. root of Zygoma	at Sphenoid	at Spine	at infra-temporal ridge	Height: Inter Auricular	Basi-Bregmatic
24 B. 1	166	163	165	158	97	68	29	134	80	100	121	70	73		133	120
3	174	170	174	166	93	67	26	139	84.5	101	122	76	77		142	125
4	182	171	179	167	95	68	30	139	83	102	127	74	68		130	116
5	170	167	169	163	95	66	29	145	80	98	123	73	69		138	126
6	178	171	179	167	96	68	28	135	82	97	120	74	72		128	120
7	173	173	165	165	94	68	27	140	90	107	132	78	72		135	120
8	169	159	164	148	94	68	26	152	91	105	134	75	65		141	125
9	174	168	170	163	99	66	33	132	76	90	113	62	63		125	115
10	168	160	168	161	93	65	28	132	81	110	116	68	63		130	115
12	179	173	179	169	99	67	33	141	90	110	131	82	75		145	128
15	161	157	159	153	92	68	28	140	80	98	125	73	71		131	128
16	186	175	183	168	96	69	27	145	79	100	123	76	73		135	123
17	180	177	177	173	97	69	28	143	86	108	128	74	78		141	125

Chinese

Cat No. 22·C	Length							Width						Height	
	Glabella to Greatest	Glabella to Inion	Nasion to Greatest	Nasion to Inion	Nasion to Basion	Nasion to Vomer	Vomer to Basion	Greatest Intermastoid	at stylo mastoid foramina	at post root of Zygoma	at sphenoid spine	at infra temporal ridge	Inter Auricular	Basi Bregmatic
3	166	163	161	157	93	62	31	133	90	67	119	67	66	129	114
5	173	171	173	168	104	73	31	139	91	73	123	73	72	132	116
6	179	176	176	170	101	67	34	142	105	72	130	72	77	127	123
16	172	164	169	158	98	69	29	134	95	77	118	70	70	132	117
17	175	171	171	164	98	68	31	136	95	71	121	74	71	136	119
21	175	168	172	164	96	64	32	137	104	74	120	77	74	133	115
24	172	165	172	162	103	71	32	141	107	77	100	75	73	141	125
25	172	165	171	163	101	71	30	147	110	75	128	75	79	139	120
27	183	178	178	171	101	72	29	140	102	76	125	70	65	135	120
28	177	189	175	165	95	69	26	132	97	70	120	71	65	130	117

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Malay.

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Cat. No															
TA 1	175	169	175	168	93	66	27	140	98	83	118	72	71	122	115
3	182	174	180	163	96	70.	27	146	93	81	125	72	72	126	115
5	188	176	187	173	101	74	27	144	95	82	119	67	70	131	120
7	185	177	183	173	97	71	26	141	96	82	119	70	66	132	122
10	191	178	185	168	97	66	31	143	100	81	123	67	70	126	115
17	187	175	183	169	102	72	30	148	100	87	125	77	67	128	121
13	195	182	194	178	100	68	32	138	95	85	120	67	71	136	119
14	187	174	184	169	97	68	29	143	98	80	120	69	71	130	121
18	171	167	170	164	93	67	26	135	101	85	120	75	74	120	110
1B1	187	175	185	170	98	71	27	144	101	84	121	70	71	125	111
	1848	1747	1826	1700	981	690	297	1422	977	828	1210	706	703	1276	1169

Length — Width — Height

Cat. No.	Glabella Greatest	Glabella Inion	Nasion Greatest	Nasion Inion	Nasion Basion	Nasion vertex	Vertex Basion	Greatest	Inter-mastoid	at slight root of Zygoma	at post of sphenoid	at spine of temporal	at Infra orbital ridge	Inter Auricular	Basi Bregmatic

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English

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	Length							Width					Height		
Cat No. 28·F	Glabella – Greatest	Glabella to Incis	Nasion – Greatest	Nasion to Incis	Nasion to Basion	Nasion to Vomer	Vomer to Basion	Greatest	Inter meatal	at Spine of Sphenoid	at post root of Zygoma	at Infra temporal ridge	at Stylo mastoid foramina	Inter Auricular	Basi Bregmatic
5	173	170	171	165	95	31	60	128	96	64	111	60	73·5	122	135
6	192	188	187	182	105	31	74	138	104	68	124	62	76	126	138
9	180	175	176	169	104	32	70	138	109	72	122	66	83	126	143
10	181	173	181	169	104	31	72	138	110	71	122	65	77	124	138
11	184	176	183	172	115	33	80	137	115	72	128	61	87	125	144
13	173	167	174	165	98	32	66	147	117	74	123	66	84	120	136
15	185	179	179	171	101	31	70	137	106	72	133	66	85	120	136
16	171	182	170	160	96	31	66	134	102	68	116	63	81	119	133
17	186	182	184	174	103	30	74	141	110	75	120	68	83	123	135
19	181	177	176	170	99	30	68	140	107	77	121	71	84·5	125	134
23	187	175	185	170	104	30	74	141	102	72	122	69	80	123	139
26	180	172	178	167	100	32	69	137	105	71	123	65	76	124	135
27	184	179	181	176	106	32	75	137	113	73	125	68	89	126	141
32	176	168	175	161	101	33	68	141	103	68	122	62	85	127	139
34	178	173	178	170	102	34	68	129	104	64	115	64	78	119	133
35	185	176	182	169	101	30	71	43	101	60	118	60	76	125	131
39	191	188	187	182	100	31	73	139	111	81	123	70	82	130	143
40	185	184	188	167	102	30	72	131	99	66	115	64	80	120	131
41	188	183	186	177	100	32	74	143	103	75	126	71	83	125	141
42	189	185	185	180	100	30	70	135	111	75	129	66	84	127	145

Sandwich Islands.

Cat. No 26·E	Length							Width					Height		
	Glabella - Greatest	Glabella t Incis	Nasion - Greatest	Nasion t Incis	Nasion t Basion	Nasion t Vertex	Vertex t Basion	Greatest	Inter Mastoid	at Stylo Mastoid Foramina	at post. root of Zygoma	at Sphenoid	at infra temporal ridge	Inter Auricular	Basi Bregmatic
11	174	163	174	161	93	66	28	135	94	76	110	69	66	130	116
14	176	158	176	150	93	65	29	132	87	75	107	69	66	129	116
16	180	168	178	164	98	67	30	138	85	80	117	67	73	126	113
17	184	179	182	171	96	70	26	140	95	79	115	71	69	130	116
18	169	160	168	155	92	75	27	122	88	75	117	64	69	119	113
20	163	149	161	143	85	58	27	130	86	77	115	64	63	127	114
21	169	161	165	156	88	61	28	132	90	79	109	67	62	120	115

Bush.

Cat. No	Length							Width						Height	
	Glabella to Greatest	Glabella to Inion	Nasion to Greatest	Nasion to Inion	Nasion to Basion	Nasion to Vomer	Vomer to Basion	Greatest Intercrestal	Intermastoid	at clyl at post at Spin. at Infra-orbit root of zygoma			temporal ridge	Inter Auricular	Basi-Bregmatic
XXX.1.A															
1	177	176	173	170	98	69	28	138	111	78	123	70	69	135	117
2	177	169	175	163	105	74	31	136	118	79	125	69	65	134	118
3	195	186	191	180	106	76	30	136	111	79	122	75	70	135	129
4	192	192	186	186	105	75	30	131	119	87	129	78	67	138	120
12	179	170	177	163	98	70	28	139	118	79	120	70	69	137	125
14	197	195	191	187	106	74	31	142	111	86	130	79	77	125	125
17	179	171	174	161	98	71	27	139	110	83	125	71	67	136	124
19	191	177	189	171	104	72	32	136	100	77	118	72	66	140	122
23	198	184	184	178	114	71	33	147	115	80	123	72	65	141	127
25	176	171	175	168	95	68	27	136	113	86	130	78	70	132	120
26	195	186	193	182	109	75	34	144	112	90	130	76	72	137	124
27	189	192	187	188	115	74	36	140	117	91	130	80	65	148	129
29	189	182	187	177	104	74	30	134	117	82	122	72	67	137	124
30	173	172	173	169	105	71	34	134	112	81	123	72	67	136	115
32	179	167	177	164	95	69	24	140	114	83	120	75	67	135	124
42	172	166	172	162	117	71	36	136	118	81	126	75	71	138	123
52	188	180	188	177	106	73	34	139	108	79	120	71	72	143	130
57	190	179	187	173	102	72	30	137	117	81	124	74	65	135	122
58	190	182	184	172	101	70	31	152	112	82	123	71	68	137	128
60.	184	172	183	177	103	71	33	139	109	83	126	78	67	144	126

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Maori.

Cat No. Ub. L.	Length							Width					Height		
	Glabella Greatest	Glabella to Incisivi	Incisivi Greatest	Incisivi to Incisivi	Incisivi to Lacrimal	Incisivi to Vomer	Vomer to Incisivi	Greatest	Inter. Orbital	at Slight constriction	at post orbital Zygoma	at Sphenoid Zygoma	at Infra temporal Crest.	Inter Auricular	Basi. Bregmatic
42	188	181	185	174	104	73	32	132	104	83	122	77	72	128	117
54	196	192	193	187	113	81	33	143	112	93	131	79	78	141	127
65	185	182	181	175	107	73	36	129	117	85	122	75	72	136	118
76	176	172	175	170	101	71	31	126	106	83	121	74	74	133	115
47	193	192	191	187	111	76	36	133	110	87	125	76	73	140	122
108	184	181	182	177	104	68	37	130	114	91	128	79	74	125	119
131	181	176	179	171	105	70	37	140	106	86	132	81	65	137	119
141	170	169	167	165	93	67	27	146	99	87	128	76	73	124	112
16	181	177	179	171	108	75	34	139	109	95	132	82	72	139	121
17	183	179	180	172	96	70	28	139	102	85	121	72	70	130	120
18	187	183	184	178	106	74	34	129	114	80	123	74	72	137	121
21	178	175	177	174	99	69	31	134	117	83·5	126	76	68	133	117
22	189	187	186	183	108	74	35	130	115	93.	125	78	75	142	125.

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Eskimo

Cat No. XXX·7	Length							Width						Height	
	Glabella to Greatest	Glabella to Incisors	Nasion to Greatest	Nasion to Incisors	Nasion to Basion	Nasion to Vomer	Vomer to Basion	Greatest Parietal	Interorbital at Stereotaxic Frontal	Interorbital at Postorbital Processes	Zygomatic Breadth at Stereotaxic	Zygomatic Breadth at Postorbital Processes	Interporal Breadth at Temporal Ridges	Basion to Bregma	Basion to Alveolar
1	185	181	177	173	107	75	30	131	106	82	122	71	71	133	116
2	178	168	173	160	97	66	30	132	97	78	121	70	67	103	115
3	186	177	181	171	100	68	02	139	98	75	115	69	69	130	118
4	180	167	176	158	101	69	32	129	109	80	118	69	65	131	117
5	181	179	173	169	95	66	30	133	97	78	116	70	67	133	118
6	180	176	176	170	108	78	30	125	97	79	111	67	64	136	116
7	190	180	186	173	99	70	28	141	100	83	127	76	42	135	127

Tasmanian

Average measurements for each Group of Skulls.

	Length							Width						Height	
	Glabella – Greatest	Glabella to Inion	Nasion – Greatest	Nasion to Inion	Nasion to Basion	Nasion to Vomer	Vomer to Basion	Greatest	Intermeatal	at stylo mastoid foramina	at post. root of zygoma	at sphenoid	at infra. temporal ridge	Intern. Auricular	Basi Bregmatic
Sandwich Is	182·45	176·1	179·95	170·8	101·8	71·05	31·4	137·9	106·4	81·4	121·9	71·2	65·36	123·8	137·45
Australian	181·86	173·95	177·77	167·9	100·14	70·26	30·24	128·08	94·44	78·82	114·64	68·63	67·76	117·67	133·2
Maori	185	178·8	182·3	173·4	104·25	72·25	31·1	138·75	113·1	82·3	124·9	73·9	68·3	123·8	138·1
Negro	184·77	180·44	183·22	175·44	104·1	72	32·32	135·5	103·22	82·22	118·11	71·55	71·55	122·55	137
Chinese	173·84	168	171·84	163·15	95·38	67·46	28·61	140·07	102	83·3	124·23	73·30	70·61	121·53	134·92
New Guinea	174·37	168·5	171·87	164·06	99	68·93	29·5	128·81	95·72	78·5	116·25	68·06	64·75	99·68	117
Admiralty Is.	179·3	171·3	177	166·4	96	68	28	127·9	95·3	76·3	115·8	68·1	63·8	118·2	130·1
Tasmanian	182·8	175·48	177·38	167·71	101	7028	30·85	132·85	100	79·3	118·5	77·55	67·85	118·16	128·71
Bush	173·55	161·42	172	157·14	92·11	64·5	28	132·71	90·71	77·28	112·83	67·28	66·85	114·71	125·85
English	184·8	174·7	182·6	170	97·4	69·3	28·2	142·2	97·7	83·3	121	70·6	70·3	116·9	127·6
Eskimo	184	177·38	181·46	175·69	104·23	72·38	33·07	134·61	109·61	87·04	125·84	76·92	72·15	119·46	134·23
New Caledonia	185·09	173·9	181·54	168	99	69·25	30·36	130·81	102·45	79·22	117·45	67·37	65·25	124·36	137·09
Scotch	184	180·25	181·65	170·15	99·05	69·6	28	143·85	95·45	84·34	124·75	72·25	70·55	118·3	130·4
Chatham Is.	186·53	175·53	183·93	169·26	104·66	73·2	31·8	140·86	107	82·6	104·6	72·4	68·53	121·93	135·6
Bengali	176·5	168	174·3	163·3	97·9	67·8	30·4	133·7	98·6	82·9	115·8	70·5	68·7	119·5	133·2
N.Am. Indian	175·5	169·6	173·8	165·6	99·7	70·3	30·1	141·6	103·7	83·7	128·2	73	72·8	121·1	135
Burmese	174·1	169·7	171·3	165·6	100·4	70·5	30	140·5	105·3	86	125·5	74·9	72·1	122·8	136·4
Malay	174·4	169·1	171·8	164·2	99	68·6	30·5	138·1	99·6	80·3	121·93	72·4	71·2	118·9	134·4
							21.								
Gorilla	188				136·25	97·25	48·5	136·25	131·5	82·7		58·5	66·25	97·75	108·5
Chimpanzee	134				106·5	68·5	42	115·5	106	60·5		55·5	58	75·5	92
Orang.			122·5	121·5	87·25	58·5	34·5	106·25	97·5	68·5		47·5	55·25	80·25	90·75

Measurements of the base taken from the dioptograph tracings.

Cat. No. I·B.	Stylo mastoid width (base line)	Half of base line	Length of: Left petrous	Left axis of petrous	Right axis	Right petrous	Left (mid. line)
19	82·5	41	33·5	58·5	53	3[illegible]	36
64	91·5	47	33	57	55	33	33
94	70	34·5	24	54	51·5	25	40
57	83	40	33	54·5	54	34·5	36·5
114	86	42·5	35	55	55·5	32	34
115	91	46·5	35	60·5	62	34	48
116	95	47·5	35	62	62·5	34	38
118	93	46	36	64·5	62	35	44
119	87	41	33	55	58·5	33·5	36
120	87·5	44	31	68·5	66	28	41
125	76	36	30	53	55	31	37·5
156	72·5	36	35·5	55	55·5	34	40
156	84·5	42·5	32·5	54	52·5	31·5	34
158	83	41	32	55	56	33	37·5
162	81	39	34	52·5	53	34	35·5
163	83	41	36	55	59·5	35	37
194	80	41	33	61	56·5	33	46
170	82	41	33·5	57	59·5	35	40
179	88	45·5	33	62	60	35	42
186	87	45	27·5	59	67	27	40

Scotch

Cat No 28·9.	Stylo mastoid width (base line)	Half of base line	Length of: Left petrous	Left axis of petrous	Right axis	Right petrous	Left (mid. line)
2	82	41	36·5	63	58	34·5	44
5	81	42	33·5	60	58	33	42
6	82	41	35	68	57	36	41
7	77	39	32·5	56	57	30	40
8	83	43	35	62	59	32	43
10	78	38	34·5	60	61	37	46
11	85	43	36	62	62	37	45
12	84	42	35	62	59	32	45
13	85	44	38	65	64	38	49
14	87	44	35·5	65	64	35	45
15	84	43·5	36	63	60	37	45
16	82	42	34·5	59	57	33	41
17	82	40	35	57	61	35	40
18	82	41	33	58	57	37·5	39·5
1552	86	42·5	35·5	67	65	40	52

Morioni

Cat. No 22C	Stylo mastoid width (base line)	Half of base line	Length of Left petrosus	Left axis of petrosus	Right axis	Right petrosus	Left nasal line
5	81	39	36	58	59	36	42
6	79	39	33	58	58	33	42
16	78	38	31	51	54	34	34
17	78	40	32	54	55	33	37
21	82	41	31	58	59	33	40
24	85	40	35	56	61	36	~~40~~
25	87	43	37	57	59	34	39
27	81	42	32	58	58	~~29~~	~~41~~
28	75	35	30	50	56	32	37
3	77	39	31	54	52	31	40

Malay

Cat No.	Stylo mastoid width (base line)	Half of base line	Length of Left petrosus	Left axis of petrosus	Right axis	Right petrosus	Left nasal line
2	76	38	30	53	54	30	35
3	75	38	31	49	49	30	32
5	76	36	34	55	55	33	39
6	77	38	32	51	53	32	35
7	73	37	31	54	50	33	39
8	78	40	35	57	57	34	41
9	71	35	32	56	51	31	40
10	80	41	32	61	58	32	45
11	76	40	37	59	53	35	42
14	81	40	35	55	54	34	36

Admiralty Islands

Cat. No. 28 H	Stylo mastoid Width (base line)	Half of base line	Length of Left zygoma	Left axis of zygoma	Right axis	Right zygoma	Left naso-basal line
2	81	41	30	57	53	30	40
3	81	41	34	55	57	33	38
4	80	42	37	58	58	35	38
5	78	36	31	48	47	30	30
7	74	36	33	52	65	34	39
8	76	39	35	60	61	33	47
11	72	38	28	52	49	29	35
12	82	41	31	53	55	26	34
14	75	37	31	53	53	32	38
15	83	41	33	60	58	36	43
19	76	38	33	57	55	36	43
22	82	40	30	60	52	29	41
24	82	42	37	57	60	34	39
25	78	39	35	53	53	36	35
13	82	42	30	51	51	32	32
1	75	37	32	56	53	32	40

New Guinea

Cat. No.	Stylo mastoid Width (base line)	Half of base line	Length of Left zygoma	Left axis of zygoma	Right axis	Right zygoma	Left naso-basal line
1	82	40	33	60	60	35	45
2	75	38	33	56	54	33	42
3	78	41	33	55	57	33	39
4	80	40	34	55	58	35	39
5	78	40	30	51	55	31	34
6	79	38	35	58	55	34	41
7	83	42	31	58	58	34	41

Tasmania

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Cat. No. 26.F	Stylo Mastoid Width (base line)	Half? Nasal line	Length of: Left petrous	Left cavis of petrous	Right Cavis	Left Right petrous	Left Mid. line
2	73	36	31	60	46	30	33
4	75	35	32	58	68	35	46
5	80	44	37	63	62	37	44
6	79	38	38	56	60	40	45
7	83	43	40	65	61	39	49
8	86	44	36	59	58	35	40
12	82	42	36	62	62	35	45
17	86	43	37	62	64	37	46
18	87	44	40	63	60	39	44

Negro

Cat No 21.A	Stylo Mastoid Width (base line)	Half? Nasal line.	Length of: Left petrous	Left cavis of petrous	Right Cavis	Right Petrous	Left Mid line
2	83	41	32	57	59	34	40
3	81	40	32	58	61	33	42
5	82	40	31	50	52	34	35
9	80	39	35	55	58	38	41
11	80	39	33	61	61	35	46
12	80	39	32	55	58	36	40
15	83	42	36	59	58	35	42
17	85	41	37	57	60	37	40
22	85	41	35	59	65	34	41
24	90	45	35	60	57	37	40

Bengali

Cat. No 31. A	Stylo mastoid width (baseline)	Half of base line	Length of. Left petrous	Left axis of petrous	Right axis	Right petrous	Left fmd line
1	78	40	37	56	51	33	39
2	79	39	34	59	57	35	43
3	79	38	32.5	55.5	57	34	41
4	87	44	39	61	61	38	43.5
12	79	39	33	57	55	34	41
14	86	39	31	55	68	31	41
17	83	42	33.5	63	59	34	43
19	77	37	32	55	54	38	40
23	80	41	35	59	60	34	44
25	85	43	33	61	59	34	45
27	90	46	42	67	64	41	48
29	82	41	37	56	58	38	40
30	82	41	34.5	57	54	35	38
32	83	40	34	57	61	32	41
42	88	41.5	37	58	59	36	45
56	79	38	36	57	62	36	42
57	81	41	37	56	58	34	38
58	82	41	34	56	57	36	40
60	83	43.5	35	59	53	33	39
26	90	45	35	62	61	35	38

Maori

Cat. No 32. B	Stylo mastoid width (baseline)	Half of base line	Length of. Left petrous	Left axis of petrous	Right axis	Right petrous	Left fmd line
3	82	41	34	52	58	37	37
4	84	42	31	62	56	30	45
5	83	40	32	52	61	32	35
10	83	40	34	52	58	34	35
13	89	45	35	59	59	35	38
15	86	43	33	57	60	37	40
17	76	38	30	54	52	33	39
18	84	47	30	63	57	38	46
27	79	40	35	59	60	37	43
31	91	46	35	62	58	37	41

North American Indian

Cat. No. XXVIII.F	Stylo Mastod width (base line)	Half of base line	Length of Left Petrous	Length of Left Axis of Petrous	Length of Right Axis of Petrous	Length of Right Petrous	Length of Left mid line
5	73·5	32	32	51	52	33	36
6	76	39	32	53	53	35	38
9	83	43	38	60	57	35	41
10	77	38	35	58	57·5	34·5	43
11	84	41	31	64	63	39	49
13	84	40·5	34	54	58	34	35
15	85	42·5	33·5	57·5	58	33	39
16	81	41	35	54	53	35	36
17	83	40·5	30·5	60·5	63·	33	47
19	84·5	42	35	56	53·5	32	35
	80	40	31	55	57	32	37·5
26	76	39	35	59	54	33	43·5
27	89	44	41	60	64	38	40
32	85	45	36	61	57	34	41
34	78	41	36	56	56	37	40
35	76	38	30	54	52	33	39
39	82	43	39	64	63·5	40	48
40	80	38	33	55	57	37	42
41	83	41	32	52	60	34	42
42	85	43	33	63	61·5	36	47

Sandwich Islands.

Cat No 28.H.	Stylo Mastod width (base line)	Half of base line	Length of Left Petrous	Length of Left Axis of Petrous	Length of Right Axis	Length of Right Petrous	Length of Left mid line
1	72	35	30	50	49	31	39·5
2	77	39	31	53	53	33	35
7	84	40	31	54·5	54·5	32	33·5
4	77·5	37·5	31	56	56	34	36·5
5	81	40	33	60	60	35	41·5
6	75	37	30	57	57	30	36·5
3	75	38	35	55	55	34	36
9	80	40	33	52	52	35	40
10	84	42·5	36·5	54	54	36	40
12	82	42	35	58	58	36	39
14	84	40	34·5	61	61	35	40

New Caledonia

Cat. No	Stylo Mastoid Width (B.S. Base Line)	Half? of base line	Length of. Left Petrous	Left Auris	Right Auris	Right Petrous	Left Meat. Line
16C41	83	40·5	34	56	60	36	41
5	93	46·5	42	66·5	64	41	48
6	85	44	36	61	57	37	42·5
7	83	40	35	60	58	35	44
9	87	43·5	34	63·5	62	35	45
10	91	46	35	67	64	37	49
13	86	44	36	62·5	55	35	43
14	87	42	37	62	62	34	45
16	95	45	37	57	65	43	36
17	85	42	32	56	57	33	38
18	80	40	33	61	58	32·5	45·5
21	83·5	43	35	62	59	35	44
22	93	45	40	62	65	42·5	43

Eskimo.

Cat. No. 24.B.	Stylo Mastoid Width (base line)	Half? of base line	Length of. Left Petrous	Left Auris of Petrous	Right Auris	Right Petrous	Left Meat. Line
1	80	40	35·5	56	60	35	40
3	84·5	41·5	36	57	54	32·5	35·5
4	83	41	36	54·5	56	36·5	36
5	80	42	33	56	48	31	34
6	82	40	36	58	59	35	40
7	90	44	36	56	57	35	34
8	91	43	36·5	55	63	36	36
9	76	37	31·5	54	52·5	34	38
10	81	40	35	52·5	53	33	37·5
12	90	46	36	61	60	36	41
15	80	41	32·5	56	48	31	34
16	79	42	36·5	58	53	32	28·5
17	86	44	37	61	60	38	43·5

Chinese

Cat. No.	Width at styl. mastoid foramina l.s.	Half of base line l.s.	Length of. Left perp.	Left ant. lat.	Right ant. lat.	Right perp.	Left med. lat.
1622	80	40·5	35	61	55	35	45
1620	75	39·5	36·5	55·5	52	34	39·5
1619	71	35	30	50	52	30	36
1618	80	38	37	55	57	37	39·5
1617	74	38·5	31	52·5	49·5	30	36
1616	75	38	32	52	54	32	37
1615	44·5	37·5	33	50	51	30	33·5
1614	73	37	32	49	51	32·5	33
1613	82	40·5	36	56	58	36	38
1612	84	45	37	61	59·5	36	43
1611	76·5	39·5	35	58	57	33	42
1609	~~80~~	38·5	32	54	55	33	38·5
1609	80	39	35·5	56	59	35	41
1608	76	36·5	35	55	54	34·5	39
1607	80·5	40	36	57·5	56	33	40
1606	80·5	40	37	49·5	51·5	32	30
1605	77	38·5	33	54	53·5	32	37·5
1604	75	36·5	34·5	54·5	54	32	41
1603	76	39	35·1	55	52	36	39
1602	76	37	31·5	52	50	32	36
1601	79	37·5	34·5	50·5	50	30·5	34
1600	76·5	39	34·5	54·5	59	34	39

Cat. No.	Styl. mastoid width l.s.	Half of base line	Length of. Left perp.	Left ant. lat.	Right ant. lat.	Right perp.	Left med. lat.
1365	79	39	34	57	57	32	41
1586	78	39·5	31·5	55·5	51·5	32·5	38
1585	82	41	33·5	55·5	56	32	37·5
1584	83	41	35	62	62	37·5	48
1553	72	36	33	58	57	34	40
1412	75·5	38	31·5	56	53	33	35
1382	80	39	33·5	55	55	32	44
1266	81	40	35	60	59·5	34·5	45
1363	83	42	38	60	61·5	37·5	49
1389	79	40	33·5	50	55	35·5	40
1409	79	39	33	55	52·5	33·5	35
1410	80	39·5	35	53·5	54	35	37
1270	76	37	31	52·5	54	34	38
1386	79	38·5	33·5	55	55	35·5	38
1411	84	41	35	57	57	35	38
1360	82	39·5	33	56·5	57	31·5	39
1381	79	39·5	33·5	56	55	34	37
1362	79	40·5	34·5	56	52·5	31·5	36
1376	82·5	42	35	57	58	36	39·5
1358	84	38·5	32	55	54·5	33	39·5
1361	76	39	35	57	52	32	42
1377	78	40	35	53·5	55	33·5	39

Cat. No.	Width at Stylo mastoid foramina	Half of base line	Length of: Left petrous	Left cranii	Right cranii	Right petrous	Right meat. line
1380	79	40	32.5	56	56	35.5	39
1384	81	40	32	60.5	58.5	33	40.5
18[illegible]	78	38	33	55	57	33.5	40
1375	86	44	39	61.5	59	32	43
1252	79	41	33	53	54	32.5	38
1367	80	42	38.5	61	5[illegible]	33.5	42
1254	84	42	36	57.5	62	37.5	44.5
1366	89	39	32.5	56	57	33	40
14[illegible]	90	45.5	37	64	62.5	35	44
1405	73	34.5	30	54	54	30	38
1526	78.5	39	38.5	57	55	37	40
1269	78	38	31.5	52.5	55	33.5	37.5
1267	77	39	34	54	52.5	34	39
1622	79	39.5	34	56	59	34	45

Cat No.	Width at Stylo mastoid foramina	Half of base line	Length of: Left petrous	Left cranii	Right cranii	Right petrous	Right meat. line
11	76	39	36	55	54	35	38
14	75	38	35	55	53	34	39
16	80	42	34	55	53	33	36
17	79	33	34	52	55	33	39
18	75	37	37	58	57	36	43
20	77	39	33	52	53	34	35
21	79	40	33	54	53	35	36.

Australian (cla.) Bush.

Cat. No. I.B.	Width at stylo maxillo foramen	Half base line	Length of fetrous L	Length of axis L	Length of axis R.	Length of fetrous R	Length of max line L
1	83	41	33	56	55	32	39
3	82	39	30	60	56	33	44
5	83	41	28	51	51	28	32
7	82	42	34	54	57	35	42
10	82	40	33	53	56	33	35
11	87	43	33	57	61	35	38
13	86	41	32	54	59	34	35
14	80	42	30	57	59	37	41
18	85	43	32	54	59	37	41
I.B.1	82	40	32	56	57	33	35

English

Cat No.	Width at stylo maxillo foramen	Half of base line	Length of left fetrous	Length of axis L	Length of axis R.	Length of fetrous R	Length of max line L
4	83	41	33	56	56	35	38
6	90	45	35	54	58	35	34
7	85	43	36	51	63	37	45
8	82	41	33	58	56	33	41
9	82	42	37	59	59	36	40
11	88	44	40	62	63	40	45
12	79	40	31	57	55	32	40
13	81	40	34	56	55	35	40
18	91	46	34	62	60	35	42
19	92	45	34	59	63	38	40

Burmese.

	Width at styl-mastoid foramina: 1st base line	Half of base line	Length of petrous L	Length of axis of petrous L	Length of petrous R.	Length of petrous mid. line L	Length of mid line R.	
English	83·8	41·2	32	55·2	56·7	33·1	38·1	38·1
Scotch	84·34	42·91	32·93	57·28	57·88	32·65	38·86	39
Eskimo.	87·04	43·19	35·7	61·27	60·39	36·46	43·38	42·5
Moriori	83·13	41·72	35·03	61·66	59·86	35·13	44·1	43
Maori	82·3	41·05	37·37	58·82	58·4	35·05	41·67	41·67
Tasmanian	79·3	39·86	32·71	56·14	58·71	33·57	40·14	39
Sandwich Is.	81·4	40·57	34·1	57·55	57·5	34·87	40·9	40
New Guinea	78·17	39·43	32·5	55·12	54·37	32·31	38·25	38
Chinese	83·28	41·65	35·24	56·89	56·75	34·37	38·75	39·75
Bush	77·28	38·28	34·57	55·4	54	34·28	38	39
Australian	78·82	39·34	33·85	55·58	56·21	33·56	39·22	39
Admiralty Is.	76·3	38·3	32·9	55	53·1	32·4	38	37
New Caledonian	79·22	39·18	33·54	55	55·41	33·63	38·41	38·41
Negro.	82·22	41	36·32	59·72	59	36·32	43·55	42
Bengali	82·9	40·7	33·8	57·1	58·9	35·3	40·7	39
North Amer Indian	83·7	41·8	32·9	57·2	57·9	35	39	38·5
Burmese.	85·8	42·7	34·7	57·4	58·8	35·6	40·5	39
Malay.	80·3	39·6	32·4	55·4	56·5	33·1	39·2	40.

Actual figures showing variation of measurements on both sides

	Stylo-mastoid Width	Half Base line	Length of petrous	Length of Axis of petrous	Length of mid line
	" Base line				
English	83·8	41·9	32·55	55·95	38·1
Scotch	84·34	42·17	32·79	57·33	38·93
Eskimo	87·04	43·52	36·08	60·33	42·94
Moriori	83·13	41·56	35·08	60 76	43·55
Maori	82·3	41·15	36·21	58·61	41·64
Tasmanian	79·3	39·65	33·14	56·42	39·07
Sandwich Is.	81·4	40·7	34·47	57·62	40·45
New Guinea	78·5	39·25	32·45	54·74	38·12
Chinese	83·28	41·64	34·80	58·82	39·25
Bush	77·28	38·64	34·42	54·57	38·5
Australian	78·82	39·41	33·7	55·89	39·11
Admiralty Is.	76·3	38·15	32·65	54·05	37·5
New Caledonian	79·22	39·61	33·58	55·2	38·41
Negro	82·22	41·11	36·32	59·38	42·77
Bengali	82·9	41·45	34·55	58	39·88
North Amer. Indian	83·7	41·85	33·95	57·65	38·75
Burmese	85·8	42·9	35·15	58·1	39·75
Ma Cay.	80·3	40·15	32·75	55·95	39·65

Results of averageing the measurements on both sides

The middle line of the skull being taken as passing through middle point of base line

	Base line	Half of Vert. line	Petrous	Length Axis of Petrous	Mid. line
English	100	50	39·31	67·67	45·71
Scotch	100	"	38·87	68·21	46·15
Eskimo	100	"	41·45	69·28	49·33
Moriori	100	"	42·19	73·09	52·38
Maori	100	"	43·99	71·21	50·63
Tasmanian	"	"	41·79	71·14	49·27
Sandwich Is.	"	"	42·34	70·66	49·69
New Guinea	"	"	41·51	70·02	48·76
Chinese	"	"	41·78	68·22	47·13
Bush.	"	"	44·54	70·61	49·81
Australian	"	"	42·75	70·98	49·61
Admiralty Is.	"	"	42·78	70·83	49·14
New Caledonian	"	"	42·38	69·67	48·48
Negro	"	"	44·17	72·22	52·01
Bengali	"	"	41·67	70	48·07
North Amer. Indian	"	"	40·56	68·75	46·29
Burmese	"	"	40·96	67·71	46·32
Malay.	"	"	40·08	68·67	49·37

Result obtained by taking the base line as 100 and proportionately increasing the other measurements.

	Width of basi-occipital	Greatest Length.
Scotch.	48·7	22·6
Esquimo.	46·23	22·53
English.	45·70	21·4
Burmese.	44·5	21·9
Moricon.	44·46	19·53
North Amer. Indian.	44·11	22·2
Sandwich Is.,	43·6	20·7
Bengalee.	43·6	22·1
Malay	43·3	20·7
Tasmanian	42·14	21·5
Negro.	41·00	20·3
Admiralty Is.	40·8	19·1
New Guinea.	40·3	19·8
New Caledonian	40·2	19·9
Bush.	38·14	18·85
Australian	40·3	21·3
Chinese	44·9	20·61
Maori	44·2	19·7.
Gorilla	148.	
Chimpanzee	61.	
Orang.	133.	